THE ROYAL CANADIAN INSTITUTE

Digitized by the Internet Archive
in 2011 with funding from
University of Toronto

http://www.archive.org/details/transactions58nort

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

TRANSACTIONS.

VOL. LVIII.

1907-1908.

EDITED BY THE SECRETARY.

NEWCASTLE-UPON-TYNE: PUBLISHED BY THE INSTITUTE.

PRINTED BY ANDREW REID & CO., LIMITED, NEWCASTLE-UPON-TYNE.
1911.

[*All rights of publication or translation are reserved.*]

TN
1
N8
v. 58-59

ADVERTIZEMENT.

The Institute is not, as a body, responsible for the statements and opinions advanced in the papers which may be read, nor in the discussions which may take place at the meetings of the Institute.

655997
12. 4. 57

CONTENTS OF VOL. LVIII.

PAGE.

ADVERTIZEMENT ii
CONTENTS iii

GENERAL MEETINGS.

1907. PAGE.

Aug. 3.—Annual General Meeting (Newcastle-upon-Tyne) 1
Election of Officers, 1907-1908 1
Annual Report of the Council, 1906-1907 2
Discussion 5
Annual Report of the Finance Committee 6
Representatives on the Council of The Institution of Mining Engineers, 1907-1908 7
Accounts 8
G. C. Greenwell Medals 13
"Presidential Address." By J. H. Merivale 15
Discussion 38
Discussion on the Explosion at Urpeth Colliery 39
"A Locking Hook for Sinking Purposes." By Henry Louis ... 56
Discussion 56
"Wolf-Bohres Electric Safety-lamp." By R. Cremer 59
Discussion 60
Aug. 29.—Excursion Meeting (Dunston-upon-Tyne) 61
Ferro-concrete Work at Dunston-upon-Tyne 61
Aug. 31.—Excursion Meeting (Felling) 66
Electric Pump at Tyne Main Colliery 66
Oct. 12.—General Meeting (Newcastle-upon-Tyne) 69
"Experiments Illustrative of the Inflammability of Mixtures of Coal-dust and Air:" Part II. By P. Phillips Bedson and Henry Widdas 71
Discussion 77
"The Strength of Cast-iron Tubbing for Deep Shafts." By John Morrow... 80
Discussion 103
Oct. 30.—Excursion Meeting (South Bank) 237
Cargo Fleet Steel- and Iron-works 237
Dec. 14.—General Meeting (Newcastle-upon-Tyne) 104
Death of Mr. M. Walton Brown 104
"On a Deficiency in the Nomenclature of Mineral Deposits." By Henry Louis 108
Discussion 109
"Notes on Mining and Engineering in America and Canada." By Walter Rowley 111
Discussion 124

1908. PAGE.
Feb. 8.—General Meeting (Newcastle-upon-Tyne) 126
Discussion of Mr. H. W. G. Halbaum's paper on "Cast-iron Tubbing: What is its Rational Formula?" 127
Discussion of Dr. John Morrow's paper on "The Strength of Cast-iron Tubbing for Deep Shafts" 133
Discussion of Prof. Henry Louis' paper on "A Locking Hook for Sinking Purposes" 151
Discussion of Prof. Henry Louis' paper "On a Deficiency in the Nomenclature of Mineral Deposits" 153
Discussion of Mr. Walter Rowley's "Notes on Mining and Engineering in America and Canada" 157
"A Simple Method of Water-stowage Employed at No. 5 Pit of the Escarpelle Mines." By Sainte-Claire-Deville ... 159
Discussion 165
April 11.—General Meeting (Newcastle-upon-Tyne) 166
Discussion of Mr. H. W. G. Halbaum's paper on "Cast-iron Tubbing: What is its Rational Formula?" and of Dr. John Morrow's paper on "The Strength of Cast-iron Tubbing for Deep Shafts" 167
Discussion of Messrs. J. W. Fryar and Robert Clive's paper on "The Sinking of Bentley Colliery" 168
"Memoir of Martin Walton Brown." By H. F. Bulman ... 171
"Demonstration of Rescue-apparatus, Felling, August 31st, 1907." Compiled by Lawrence Austin 178
Discussion 185
"Flinty Chert, Hornstone, etc." By Thomas Harker 199
Discussion 201
"The Occurrence and Commercial Uses of Fluorspar." By William Morley Egglestone 204
Discussion 231
June 20.—General Meeting (Newcastle-upon-Tyne) 241
Portraits of Past-Presidents and Secretaries 241
Discussion of Mr. W. M. Egglestone's paper on "The Occurrence and Commercial Uses of Fluorspar" 244
Discussion of Mr. Thomas Harker's paper on "Flinty Chert, Hornstone, etc." 247
Discussion of Mr. H. W. G. Halbaum's paper on "Cast-iron Tubbing: What is its Rational Formula?" 248
"Circulation and Heat Absorption in Steam Boilers." By Arthur Ross 259
Discussion 269

APPENDICES.

I.—Notes of Papers on the Working of Mines, Metallurgy, etc., from the Transactions of Colonial and Foreign Societies and Colonial and Foreign Publications 1-97
"Stanniferous and Auriferous Deposits of the Transvaal and Rhodesia." By R. Beck 1
"Mining Developments in the German Colonies." By — Schmeisser 2

APPENDICES. —*Continued.*

I. —Notes of Papers, etc.—*Continued.* PAGE.

"Uranium-ores from German East Africa." By W. Marckwald 5
"Auriferous Deposits of Madagascar." By L. Gascuel 6
"Rare Minerals from Manicaland, South Africa." By J. Couyat 8
"Native Copper in Brazilian Diabases." By E. Hussak ... 9
"Diamantiferous Deposits in Brazil." By E. Hussak 10
"Palladium and Platinum in Brazil." By Eugen Hussak ... 11
"Tourmaline-bearing Cobalt-deposits in Chile." By O. Stutzer 12
"Coal- and Lignite-fields of the Rocky Mountains." By Étienne A. Ritter 13
"Precious Chrysolite of St. John's Island, Red Sea." By L. Michel 15
"Identification of Copiapite with Jánosite." By E. Weinschenk 16
"Sulphate-of-iron Minerals: Coquimbite, Copiapite, and Römerite." By R. Scharizer 16
"Frigidite, a Variety of Tetrahedrite." By Ernesto Manasse 17
"Occurrence of Kimberlite in Fissure-veins, etc." By F. W. Voit 18
"Nepouite, a new Nickeliferous Mineral." By E. Glasser ... 19
"Paravivianite and Kertchenite, two new Minerals." By S. Popoff 19
"Yttrocrasite and Paratacamite: two new Minerals":—
(1) By W. E. Hidden and C. H. Warren 20
(2) By G. F. Herbert Smith 20
"Determination of Gold in Auriferous Sands." By Albert Fournier 20
"Manganese-ores." By Wilhelm Venator 21
"Karács-Czebe Gold-mines, Hungary." By Karl von Papp ... 22
"Mineral Industry in Russian Central Asia." By F. Thiess ... 24
"Working of Native Sulphur in Sicily and in Louisiana." By L. Aguillon 26
"Gold and Silver-mines of Arzate, Mexico." By Juan D. Villarello 28
"Metalliferous Mines of Zacualpan, Mexico." By Juan D. Villarello 29
"Use of Excavators at the Brown-coal Mines of Prussian Saxony." By M. Tornow 31
"Dynamite-explosion at the Zappendorf Bore-hole, Germany." By — Beyling 33
"Gréhant Fire-damp Indicator." Anon. 34
"Fire-damp Explosion at the Liévin Collieries, France." Anon. 35
"Explosion at the Desdemona Salt-mine, Hanover." By — Wigand 35
"Explosions in Prussian Collieries during the Year 1905." Official 37
"Explosion at the Reden Colliery, near Saarbrücken, Germany." By — Einer 40
"Fire in the Borussia Colliery, Dortmund, Germany." Official 42
"Choke-damp Disaster in an Upper Silesian Colliery." By — Steinhoff 44
"Boiler-accidents in France during 1905." Official 45

APPENDICES.—*Continued.*

I.—Notes of Papers, etc. – *Continued.*

PAGE.

"Accidents in Connection with Electrical Installations in Prussian Mines during 1905." Official 45
"Accidents in Connection with Electric Appliances at Prussian Mines during the Year 1906." Official 47
"Underground Temperatures: Values of the Geothermic Degree." By Joh. Königsberger 48
"The Distribution of Metalliferous Ores in Depth." By P. Krusch 49
"Origin of Pyropissite or 'Paraffin-coal.'" By Max Heinhold 51
"Chemical Theory of the Origin of Petroleum." By L. Pervinquière 53
"The Origin of Petroleum, etc.":—
(1) By A. F. Stahl 55
(2) By A. F. Stahl 55
"Diabases and Pegmatites as Matrices of the Diamond." By Hans Merensky 56
"The Formation of Kaolin." By H. Stremme 57
"Precious Gems and Radio-activity":—
(1) By F. Bordas 58
(2) By F. Bordas 58
(3) By Daniel Berthelot 59
"Metalliferous Mines of Styria, Carinthia, and Carniola, Austria." By — Ahlburg... 59
"Brown Coals of Bjelina, North-eastern Bosnia." By Friedrich Katzer 62
"The Fahlore and Mercury-ore Deposits of Bosnia and Herzegovina." By Friedrich Katzer 64
"Petroleum and Asphalt in Hungary." By Theodor Posewitz 66
"Iron-ores of the Payerbach-Reichenau District, Lower Austria." By Karl Redlich 68
"The Rossitz Coal-field, Moravia, Austria." By Franz E. Suess 69
"The Auriferous Rocks of Transylvania." By M. von Pálfy ... 71
"Native Copper in the Færöe Basalts." By F. Cornu 72
"The Search for Coal in Franche-Comté, Eastern France." By Eugène Fournier 73
"Coatquidan Iron-ores, Brittany." By F. Kerforne 74
"Ordovician Iron-ores of Lower Normandy." By Ch. E. Heurteau 74
"Brown-coal Deposits of the Hoher Westerwald, Germany." By F. Freise 77
"Possible New Coal-fields in the Erzgebirge Region, Germany." By C. Gäbert 79
"The Government Collieries in the Saare District, Germany." By Friedrich Okorn 80
"Iron-ore Deposits of Württemberg, Germany." By Robert Fluhr 82
"Age of the Siegerland Iron-ores, Germany." By H. Lotz ... 83
"Iron- and Manganese-ore Deposits of Oberrosbach, Germany." By — Bodifée 84

APPENDICES.—*Continued.*

I.—Notes of Papers, etc.—*Continued.* PAGE.

"Lower Carboniferous on the Eastern Border of the Upper Silesian Coal-field." By R. Michael 85

"Arsenical Ore-deposits of Reichenstein, Silesia." By O. Wienecke 87

"Auriferous Deposits of Brusson, Piedmont." By Luigi Colomba 89

"Geology of the Grozny Oil-field, Russia." By K. Kalitzky ... 89

"Pitkäranta Ore-deposits, Finland." By Otto Trüstedt ... 91

"The Mining District of Neviansk, Russia." By A. Krasnopolsky 93

"Cupriferous Deposits of Bor, Servia." By F. Cornu and M. Lazarevič 94

"Iron-ore Deposits of Northern Sweden." By R. Bärtling ... 94

II.—Annual Report of the Council and Accounts for the Year 1907-1908; List of Council, Officers and Members for the Year 1908-1909; the Charter and Bye-laws; etc. ... ... i-lxxv

INDEX 1-9

LIST OF PLATES:—

PAGE.

PORTRAIT OF MR. MARTIN WALTON BROWN ... *Frontispiece*

I. 102

II. 164

III., IV., V., VI. 184

MARTIN WALTON BROWN.

SECRETARY OF THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS AND OF THE INSTITUTION OF MINING ENGINEERS, 1891-1907.

Born on June 12th, 1854, and died on November 22nd, 1907.

(*Presented by The North of England Institute of Mining and Mechanical Engineers.*)

THE NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
AUGUST 3RD, 1907.

MR. J. H. MERIVALE, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on July 20th and that day, and of the Council of The Institution of Mining Engineers.

ELECTION OF OFFICERS, 1907-1908.

The CHAIRMAN (Mr. J. H. Merivale) appointed Messrs. C. A. Crofton, A. M. Hedley, N. B. Ridley, John Simpson, J. Southern and W. B. Wilson, jun., as scrutineers of the balloting-papers for the election of officers for the year 1907-1908.

The SCRUTINEERS afterwards reported the result of the ballot, as follows:—

PRESIDENT:
Mr. J. H. MERIVALE.

VICE-PRESIDENTS:

Mr. R. D. BAIN.	Mr. F. COULSON.	Mr. H. PALMER.
Mr. W. C. BLACKETT.	Mr. T. E. FORSTER.	Mr. J. SIMPSON.

COUNCILLORS:

Mr. R. S. ANDERSON.	Mr. T. E. JOBLING.	Mr. J. H. NICHOLSON.
Mr. J. B. ATKINSON.	Mr. J. P. KIRKUP.	Hon. C. A. PARSONS.
Mr. C. S. CARNES.	Mr. P. KIRKUP.	Mr. F. R. SIMPSON.
Mr. B. DODD.	Mr. H. LAWRENCE.	Mr. C. H. STEAVENSON.
Mr. S. HARE.	Mr. C. C. LEACH.	Mr. S. TATE.
Mr. A. M. HEDLEY.	Mr. A. D. NICHOLSON.	Mr. R. L. WEEKS.

Mr. C. S. CARNES moved a vote of thanks to the Scrutineers for their services.

Mr. J. G. WEEKS seconded the resolution, which was cordially adopted.

Mr. E. S. WOOD moved a vote of thanks to the President, Vice-Presidents, Councillors and Officers for their services during the past year.

Mr. W. B. WILSON seconded the motion, which was heartily adopted.

Mr. C. H. MERIVALE moved a vote of thanks to the representatives of this Institute on the Council of The Institution of Mining Engineers for their services during the past year.

Mr. N. B. RIDLEY seconded the proposal, which was cordially adopted.

The Annual Report of the Council was read as follows:—

ANNUAL REPORT OF THE COUNCIL, 1906-1907.

The Institute has sustained great losses through the death of Mr. John Daglish, a past-president of the Institute, and one of its original members; and through the death of Mr. William Fairbairn Hall, a member since 1858, and a vice-president, 1892-1896.

The following table shows the variation of the membership during recent years:—

Year ending August 1st.	1901.	1904.	1907.
Honorary members	28	26	21
Members	880	955	903
Associate members	122	115	108
Associates	116	163	194
Students	57	66	47
Subscribers	23	25	34
Totals	1,226	1,350	1,307

A Committee, consisting of Messrs. T. E. Forster, George May, J. H. Merivale, J. G. Weeks and the Secretary (Mr. M. Walton Brown), appointed to enquire into and report upon the decrease of the attendance at the Colliery Engineers' Classes, reported that the apparent decrease in the number of students in recent years arose from the poor quality of those attending in early years, and they were of opinion that the present students were fully capable of taking advantage of the lectures. Certain alterations in the syllabus of lectures, suggested by the Committee, were agreed to by the authorities of Armstrong College.

Mr. J. Parke Channing was appointed to represent the Institute at the opening of the United Engineering Societies' Building, New York City, in April, 1907. Mr. R. H. Prior-Wandesforde represented the Institute at the Conference of the Royal Sanitary Institute, held at Dublin, in June, 1907. The Rev. G. M. Capell represented the Institute at the Conference of the Corresponding Societies of the British Association for the Advancement of Science, held in Leicester, commencing on July 31st, 1907. The Geological Society of London will celebrate the centenary of their existence in September, 1907, and Prof. G. A. L. Lebour has been appointed to represent the Institute thereat, and will present an address.

Mr. J. H. Merivale has given evidence, as the representative of the Institute, before the Departmental Committee on the Miners' Eight Hours' Day.

G. C. Greenwell silver medals have been awarded to Mr. W. E. Garforth for his paper upon "A New Apparatus for Rescue-work in Mines,"* and to Mr. G. A. Meyer for his paper upon "Rescue-apparatus and the Experiences gained therewith at the Courrières Collieries by the German Rescue-party:"† and a bronze medal has been awarded to Mr. S. F. Walker for his

* *Trans. Inst. M. E.*, 1906, vol. xxxi., page 625.

† *Ibid.*, 1906, vol. xxxi., page 575.

papers upon "Earth in Collieries, with reference to the 'Special Rules for the Installation and Use of Electricity'"* and "The Capacity-current and its Effect on Leakage-indications on Three-phase Electrical Power-service."†

Prizes for books have been awarded to the writers of the following papers, communicated to the members during the year 1905-1906:—

"Improved Dampers for Coke-oven Flues." By Mr. William Archer, M.I.M.E.
"A Mechanical Coal-cutter in Queensland." By Mr. William Fryar.
"The Great Planes of Strain in the Absolute Roof of Mines." By Mr. Henry Wallace Gregory Halbaum, M.I.M.E.
"Corundum in Ontario, Canada: Its Occurrence, Working, Milling, Concentration and Preparation for the Market as an Abrasive." By Mr. David Gillespie Kerr, M.I.M.E.
"The Alumino-thermic Welding Process, and its Application to General Engineering." By Mr J. Stewart MacGregor.
"The Unwatering of the Achddu Colliery, with a Description of the Riedler Express Pump." By Mr. John Morris, M.I.M.E.
"Undersea Extensions at the Whitehaven Collieries, and the Driving of the Ladysmith Drift." By Mr. John Shanks, M.I.M.E.
"The Barton and Forcett Limestone-quarries." By Mr. Thomas Teasdale, M.I.M.E.
"Determination of the Specific Electrical Resistance of Coal, Ores, etc." By Mr. G. C. Wood.

At the recommendation of the Committee appointed to enquire into the treatment of coal-dust in collieries, the Council have made a maintenance-grant of £50 towards the cost of conducting further experiments on the inflammability of mixtures of coal-dust and air, together with £25 for apparatus, to Mr. Henry Widdas of Armstrong College. Dr. P. P. Bedson and Mr. Henry Widdas have read a paper, illustrated with numerous "Experiments illustrative of the Inflammability of Mixtures of Coal-dust and Air."

Members of the American Institute of Mining Engineers visited Newcastle-upon-Tyne on August 1st and 2nd, 1906, and visits to collieries, works, Bamburgh and Alnwick Castles and the Roman Wall were arranged for their entertainment. The thanks of the American Institute of Mining Engineers have been received for the courtesy shown to its members.

Excursion meetings were held at Bowburn colliery on September 10th, 1906; at Axwell Park colliery on December 5th, 1906; and at Wearmouth colliery on June 6th, 1907.

* *Trans. Inst. M. E.*, 1905, vol. xxx., page 404.

† *Ibid.*, 1906, vol. xxxi., page 526.

The thanks of the Institute have been sent to the owners of collieries, works, etc., visited during the year.

The papers printed in the *Transactions* during the year are as follows: —

"Experiments illustrative of the Inflammability of Mixtures of Coal-dust and Air." By Prof. P. Phillips Bedson, Hon. M.I.M.E., and Mr. Henry Widdas, M.I.M.E.

"Memoir of the late John Daglish." By Mr. M. Walton Brown, M.I.M.E.

"An Appliance for Automatically Stopping and Restarting Mine-wagons." By Prof. William Galloway, M.I.M.E.

"Ferro-concrete and its Applications." By Mr. T. J. Gueritte.

"Treatment of Dust in Mines, Aboveground and Belowground." By Mr. Richard Harle, M.I.M.E.

"Sliding-trough Conveyors." By Mr. M. Malplat.

"The Valuation of Mineral Properties." By Mr. Thomas Aloysius O'Donahue, M.I.M.E.

"Liquid Air and its Use in Rescue-apparatus." By Mr. Otto Simonis.

"Deposits in a Pit-fall at Tanfield Lea, Tantobie, County Durham." By Dr. J. A. Smythe.

"Bowburn Winning." By Mr. Addison Langhorne Steavenson, M.I.M.E.

"Electro-barograph for Mines." By Mr. B. H. Thwaite.

"Sinking through Magnesian Limestone and Yellow Sand by the Freezing-process at Dawdon Colliery, near Seaham Harbour, County Durham." By Mr. Ernest Seymour Wood, M.I.M.E.

The Council are pleased to report that the North-eastern Railway Company have granted reduced railway-fares to members attending general or excursion meetings of the Institute; and they trust that this concession will lead to an increased attendance.

The Institution of Mining Engineers has now entered upon its nineteenth year, and the members are to be congratulated upon its continued success, and the increasing membership of the associated institutions. Meetings were held in Hanley in September, 1906, and in London in June, 1907.

Mr. Thomas Douglas, referring to the decrease in the attendance at the colliery-engineers' classes at Armstrong College, said that it was very desirable that a large attendance should be secured.

Mr. M. Walton Brown said that it was important that colliery managers should see that those who attended these classes possessed such elementary knowledge, especially in mathematics, as would render the lectures advantageous to them.

The PRESIDENT (Mr. J. H. Merivale) moved the adoption of the Annual Report of the Council.

Mr. J. B. SIMPSON seconded the motion, which was adopted.

The Report of the Finance Committee was read as follows:—

ANNUAL REPORT OF THE FINANCE COMMITTEE.

The Finance Committee submit herewith a statement of accounts for the twelve months ending June 30th, 1907, duly audited.

The total receipts were £2,978 0s. 3d. Of this amount, £49 19s. was paid as subscriptions in advance, leaving £2,928 1s. 3d. as the ordinary income of the year, compared with £2,838 2s. 3d. in the previous year. The amount received for ordinary current-year subscriptions was £2,264 17s. and arrears £318 9s., as against £2,249 1s. and £287 16s. respectively in the year 1905-1906. *Transactions* sold realized £19 3s. 9d., as compared with £44 4s. 3d. in the earlier period; the sum received for interest on investments was £325 11s. 6d., the amount in the former year being £317 10s.

The expenditure was £2,622 13s. 3d., that for the previous year being £2,544 10s. 10d. The increase was due to expenditure in connection with the visit of the American Institute of Mining Engineers; the contribution of £75 towards the cost of experiments on coal-dust conducted at Armstrong College; and expenses incurred in the preparation of the Library catalogue. Increases are also shown in the charges for salaries and wages, heating and lighting, postages, etc., while there is a considerable decrease in the amount spent on the Wood Memorial Hall and also for printing and stationery, the latter in consequence of certain liabilities remaining unpaid at the close of the year, but carried forward and included in the balance-sheet.

The figures given above show that the income exceeded the expenditure by £355 7s., and adding to this the balance of £896 19s. 6d., a total balance of £1,252 6s. 6d. remains to the credit of the Institute. Of this amount, £499 17s. 6d. has been invested in the purchase of stock of the Newcastle and Gateshead Water Company, leaving the sum of £752 9s. to carry forward.

The names of 32 persons have been struck off the membership list in consequence of non-payment of subscriptions. The amount of subscriptions written off was £176 3s., of which £96 18s. was for sums due for the year 1906-1907, and £79 5s. for arrears. It is probable that a considerable proportion of these amounts will be recovered and credited in future years. Of the amounts previously written off, £68 16s. was recovered during the past year.

JOHN H. MERIVALE, *President.*

August 3rd, 1907.

The PRESIDENT (Mr. J. H. Merivale), in moving the adoption of the Annual Report of the Finance Committee, remarked that the financial position of the Institute was very satisfactory.

Mr. J. G. WEEKS seconded the resolution, which was adopted.

REPRESENTATIVES ON THE COUNCIL OF THE INSTITUTION OF MINING ENGINEERS, 1907-1908.

The PRESIDENT (Mr. J. H. Merivale) moved, and Mr. Thomas Douglas seconded, a resolution that the following gentlemen be elected as the representatives of the Institute on the Council of The Institution of Mining Engineers for the year 1907-1908:—

Mr. W. ARMSTRONG.
Mr. B. H. BROUGH.
Mr. C. S. CARNES.
Mr. A. G. CHARLETON.
Mr. F. COULSON.
Mr. B. DODD.
Mr. T. DOUGLAS.
Mr. J. H. B. FORSTER.
Mr. J. W. FRYAR.
Mr. W. GALLOWAY.
Mr. T. Y. GREENER.
Mr. S. HARE.
Mr. A. M. HEDLEY.
Mr. P. KIRKUP.
Mr. C. C. LEACH.
Mr. J. McMURTRIE.
Mr. G. MAY.
Mr. J. H. MERIVALE.
Mr. C. A. MOREING.
Mr. J. J. PREST.
Mr. R. F. SPENCE.
Mr. C. H. STEAVENSON.
Mr. J. G. WEEKS.
Mr. R. L. WEEKS.
Mr. A. N. L. WOOD.

The resolution was agreed to.

DR. THE TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND FOR THE YEAR ENDING

	£ s. d.	£ s. d.
June 30th, 1906.		
To balance of account at bankers	840 11 3	
„ „ in Treasurer's hands	53 9 9	
„ outstanding accounts due from authors for excerpts	2 18 6	
		896 19 6
June 30th, 1907.		
To dividend of 7½ per cent. on 179 shares of £20 each in the Institute and Coal-trade Chambers Company, Limited, for the year ending June 30th, 1907 ...	268 10 0	
„ interest on mortgage of £1,400 with the Institute and Coal-trade Chambers Company, Limited	49 0 0	
„ dividend on £340 consolidated 5 per cent. preference stock of the Newcastle and Gateshead Water Company	8 1 6	
		325 11 6
To sales of *Transactions*		19 3 9
To SUBSCRIPTIONS FOR 1906-1907 AS FOLLOWS:—		
762 members ... ... @ £2 2s.	1,600 4 0	
85 associate members ... ... @ £2 2s.	178 10 0	
159 associates ... ... @ £1 5s.	198 15 0	
46 students ... ... @ £1 5s.	57 10 0	
24 new members ... ... @ £2 2s.	50 8 0	
5 new members, not yet elected ... @ £2 2s.	10 10 0	
7 new associate members ... ... @ £2 2s.	14 14 0	
1 new associate member, not yet elected @ £2 2s.	2 2 0	
11 new associates ... ... @ £1 5s.	13 15 0	
1 new associate, not yet elected ... @ £1 5s.	1 5 0	
9 new students ... ... @ £1 5s.	11 5 0	
	2,138 18 0	
33 subscribing firms £113 8 0		
1 new subscribing firm 2 2 0		
1 new subscribing firm, not yet elected 2 2 0		
	117 12 0	
	2,256 10 0	
1 associate member, paid life-composition 31 0 0		
1 new member, paid life-composition 23 2 0		
	54 2 0	
	2,310 12 0	
Less, subscriptions for current year paid in advance at end of last year	45 15 0	
	2,264 17 0	
Add, arrears received	318 9 0	
	2,583 6 0	
Add, subscriptions paid in advance during current year	49 19 0	
		2,633 5 0
		£3,874 19 9

INSTITUTE OF MINING AND MECHANICAL ENGINEERS CR.
JUNE 30TH, 1907.

June 30th, 1907.	£	s.	d.	£	s.	d.
By *Annual Report*	45	5	0			
„ banker's charges	22	1	6			
„ circulars and advance copies of papers	64	10	3			
„ cleaning Wood Memorial Hall, offices, etc.	30	1	11			
„ electric light	28	7	0			
„ expenses of meetings	95	3	3			
„ fuel	23	0	9			
„ furniture and repairs	27	0	10			
„ incidental expenses	5	6	1			
„ insurance	13	17	9			
„ investments	499	17	6			
„ library: binding £31 6 9						
„ „ books 26 9 9						
„ „ catalogue 23 0 0						
	80	16	6			
„ petty cash	2	9	4			
„ postages: circulars £42 3 6						
„ „ correspondence 20 15 2						
„ „ publications 23 8 8						
	86	7	4			
„ panels and portraits of Presidents	48	17	0			
„ prizes for papers	24	3	0			
„ rates and taxes	6	3	6			
„ rent of offices	24	9	8			
„ *Report of the Committee upon Mechanical Coal-cutting*	2	12	6			
„ reporting of general meetings	12	12	0			
„ salaries, wages, auditing, etc.	531	6	6			
„ stationery, etc.	26	15	5			
„ telephone rent	1	5	0			
„ travelling expenses	2	15	3			
„ Treatment of Coal-dust Committee	88	6	0			
„ water rate	3	17	8			
				1,797	8	6
By The Institution of Mining Engineers	1,326	17	4			
Less, amounts paid by authors for excerpts	1	15	1			
				1,325	2	3
				3,122	10	9
By balance of account at bankers	711	4	7			
„ „ in Treasurer's hands	38	5	11			
„ outstanding accounts due from authors for excerpts	2	18	6			
				752	9	0
				£3,874	19	9

DR. THE TREASURER OF THE NORTH OF ENGLAND INSTITUTE OF MINING

		£ s. d.	£ s. d.	£ s. d.
To 931 members.				
51 of whom have paid life-compositions.				
880				
2 not included in printed list.				
882	@ £2 2s.	... ...	1,852 4 0	
To 114 associate members.				
8 of whom have paid life-compositions				
106				
1 paid life-composition.		31 0 0		
105	@ £2 2s.	220 10 0		
			251 10 0	
To 190 associates,				
1 of whom has paid a life-composition.				
189	@ £1 5s.	... ...	236 5 0	
To 56 students,				
1 paid as a member.				
55	@ £1 5s.	... ...	68 15 0	
To 33 subscribing firms		... ...	113 8 0	
				2,522 2 0
To 24 new members	@ £2 2s.	50 8 0		
1 new member, paid a life-composition ...		23 2 0		
5 new members, not yet elected	@ £2 2s.	10 10 0		
30			84 0 0	
To 7 new associate members	@ £2 2s.	14 14 0		
1 new associate member, not yet elected		2 2 0		
8			16 16 0	
To 11 new associates	@ £1 5s.	13 15 0		
1 new associate, not yet elected	@ £1 5s.	1 5 0		
12			15 0 0	
To 9 new students	@ £1 5s.	... ...	11 5 0	
To 1 new subscribing firm		2 2 0		
1 new subscribing firm, not yet elected ...		2 2 0		
2			4 4 0	
				131 5 0
To arrears, as per balance sheet, 1905-1906			419 15 0	
Add, arrears considered irrecoverable, but since paid ...			68 16 0	
				488 11 0
				3,141 18 0
To subscriptions paid in advance			... ...	49 19 0
				£3,191 17 0

AND MECHANICAL ENGINEERS IN ACCOUNT WITH SUBSCRIPTIONS, 1906-1907. CR.

			PAID.			UNPAID.			STRUCK OFF LIST.		
			£	s.	d.	£	s.	d.	£	s.	d.
By 762	members, paid	@ £2 2s.	1,600	4	0	.....			.....		
89	,, unpaid ...	@ £2 2s.	.....			186	18	0	.....		
5	,, excused payment	@ £2 2s.	.....			.....			10	10	0
5	,, dead	@ £2 2s.	.....			.....			10	10	0
21	,, struck off list	@ £2 2s.	.....			.....			44	2	0
882											
By 85	associate members, paid	@ £2 2s.	178	10	0	.....			.....		
1	,, ,, paid a life-composition		31	0	0	.....			.....		
12	,, ,, unpaid	@ £2 2s.	.....			25	4	0	.....		
2	,, ,, excused	@ £2 2s.	.....			.....			4	4	0
6	,, ,, struck off list		... ..			.....			12	12	0
106											
By 159	associates, paid	@ £1 5s.	198	15	0	.....			.....		
22	,, unpaid ...	@ £1 5s.	.....			27	10	0	.....		
8	,, struck off list	@ £1 5s.	.....			.....			10	0	0
189											
By 46	students, paid	@ £1 5s.	57	10	0	.....			.....		
5	,, unpaid ...	@ £1 5s.	.....			6	5	0	.....		
1	,, excused payment	@ £1 5s.	.....			... ..			1	5	0
3	,, struck off list...	@ £1 5s.	.....			.....			3	15	0
55											
By 33	subscribing firms, paid		113	8	0	.....			.....		
By 24	new members, paid ...	@ £2 2s.	50	8	0	.....			.....		
1	,, ,, paid a life-composition		23	2	0	.. .			... ..		
5	,, ,, not yet elected	@ £2 2s.	10	10	0	.....			... ..		
30											
By 7	new associate members, paid	@ £2 2s.	14	14	0	.....			.....		
1	,, ,, not yet elected	@ £2 2s.	2	2	0	.....			.....		
8											
By 11	new associates, paid ...	@ £1 5s.	13	15	0	.....			.....		
1	,, ,, not yet elected	@ £1 5s.	1	5	0	.....			... ..		
12											
By 9	new students, paid ...	@ £1 5s.	11	5	0	.....			.....		
By 2	new subscribing firms, paid	@ £2 2s.	4	4	0	.....			.....		
			2,310	12	0	245	17	0	96	18	0
By arrears			318	9	0	90	17	0	79	5	0
			2,629	1	0						
By subscriptions paid in advance			49	19	0	.....			.....		
			2,679	0	0	336	14	0	176	3	0
									336	14	0
									2,679	0	0
									£3,191	17	0

LIABILITIES.

	£ s. d.	£ s. d.
Subscriptions paid in advance during the current year		54 3 0
The Institution of Mining Engineers		49 18 2
The George Clementson Greenwell prize fund	100 0 0	
Less, paid for medals	67 8 4	
		32 11 8
Printing, etc.		80 0 0
Capital		12,345 1 11

We, having examined the above account with the books, vouchers and securities relating thereto, certify that, in our opinion, it is correct. We have accepted the assets, books, pictures, maps, etc., and *Transactions* and other publications as valued by your officials.

JOHN G. BENSON AND SONS,
CHARTERED ACCOUNTANTS.

Newcastle-upon-Tyne,
August 3rd, 1907.

£12,561 14 9

ASSETS.

	£ s. d.	£ s. d.
Balance of account at bankers	711 4 7	
„ in Treasurer's hands	38 5 11	
Outstanding accounts due from authors for excerpts	2 18 6	
		752 9 0
Arrears of subscriptions		336 14 0
179 shares in the Institute and Coal-trade Chambers Company, Limited (at cost) ...	4,100 0 0	
Institute and Coal-trade Chambers Company, Limited (mortgage)	1,400 0 0	
£340 consolidated 5 per cent. preference stock of the Newcastle and Gateshead Water Company (at cost)	499 17 6	
		5,999 17 6
(Of the above amount, £1,640 2s. is due to life-subscriptions account.)		
Value of *Transactions* and other publications, as per stock account	322 14 3	
Books, pictures, maps, furniture and fittings	5,150 0 0	
		5,472 14 3

£12,561 14 9

G. C. GREENWELL MEDALS.

The PRESIDENT (Mr. J. H. Merivale) presented the Greenwell medals, which had been awarded by the Council to Mr. W. E. Garforth for his paper on "A New Apparatus for Rescue-work in Mines;"* to Mr. G. A. Meyer for his paper on "Rescue-apparatus and the Experiences gained therewith at the Courrières Collieries by the German Rescue-party;"† and to Mr. S. F. Walker for his papers upon "Earth in Collieries, with Reference to the 'Special Rules for the Installation and Use of Electricity,'"‡ and "The Capacity-current and its Effect on Leakage-indications on Three-phase Electrical Power-service."§

Mr. W. E. GARFORTH wrote that he was pleased to receive the G. C. Greenwell silver medal awarded to him for his paper on "A New Apparatus for Rescue-work in Mines." He thanked the Council for their kindness, which he much appreciated. If he could, at any time, afford assistance to the Council, either with the apparatus or by giving information about the rescue-gallery, any experience that he had gained was quite at their disposal.

Mr. G. A. MEYER wrote that he esteemed it a great honour to be placed in such an enviable connection with the name of one of the founders of the Institute by the kind resolution of the Council. In receiving this award, he remembered the time, just twenty years ago, when, as a mining student, he made his first studies of British mine-engineering in the Royal Mining, Engineering and Industrial Exhibition at Newcastle-upon-Tyne, in the mines of the neighbourhood, and in the library of the Wood Memorial Hall. He had remained in close touch with British mine-engineering since that time, and he had profited and widened his own knowledge by this valuable connection. He was proud to feel that this connection was strengthened by the kindness of the Council of The North of England Institute of Mining and Mechanical Engineers in presenting the G. C. Greenwell silver medal to him, and he expressed his heartiest thanks for the honour which the Council had been good enough to confer on him.

Mr. SYDNEY F. WALKER thanked the Council for the honour which they had conferred upon him by awarding him the G. C.

* *Trans. Inst. M. E.*, 1906, vol. xxxi., page 625.

† *Ibid.*, 1906, vol. xxxi., page 575. ‡ *Ibid.*, 1905, vol. xxx., page 404.

§ *Ibid.*, 1906, vol. xxxi., page 526.

Greenwell bronze medal for his papers. It was certainly pleasant to know that one's work was appreciated, and he had always felt that his writings were especially appreciated in the North of England.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. FRITZ BAARE, General Manager of Steel-works, Bochum, Westphalia, Germany.

Mr. ALBURTO BEMENT, Mechanical Engineer, American Trust Building, Chicago, Illinois, U.S.A.

Mr. RALPH RICHARDSON BROWN, Colliery Manager, Pekin Syndicate, Honan, North China.

Mr. JAMES CHALMERS, Civil Engineer, Obras do Porto do Rio de Janeiro, Caixa 711, Rio de Janeiro, Brazil, South America.

Mr. BERENT CONRAD GULLACHSEN, Mining Engineer, Hotel Norge, Bergen, Norway.

Mr. FREDERICK WILLIAM HYLTON, Mining Engineer, Ryhope Colliery, Sunderland.

Mr. REGINALD CHARLES MORTON, Electrical Engineer, 23, Lovaine Crescent, Newcastle-upon-Tyne.

Mr. ARTHUR HERBERT SHEEPSHANKS PAGE, Under-manager, Etherley, Bishop Auckland.

Mr. CHARLES EDMUND RAY, Mining Engineer, Whinfield, near Ulverston.

Mr. FRED RICHARDS, Mine-manager and Assayer, Blaenau, Compton Road, Canonbury, London, N.

Mr. JEAN ADOLF ROELOFSEN, Coke-oven Manager and Chemical Engineer, Post Office Buildings, Middlesbrough.

Mr. JOSEPH SEYMOUR ROWE, Colliery Manager, Metropolitan Colliery, Helensburgh, New South Wales, Australia.

ASSOCIATE MEMBER—

Mr. PERCY COLLINSON LEAKE, Thomas Terrace, Blaydon-upon-Tyne, S.O., County Durham.

ASSOCIATES—

Mr. DAVID MILLNE, Coal-miner, 1, Burdon Street, Bedlington, S.O., Northumberland.

Mr. HENRY HERBERT NICHOLS, Under-manager, Kibblesworth, Gateshead-upon-Tyne.

Mr. ROBERT RATCLIFFE, Deputy, Beamish, S.O., County Durham.

STUDENTS—

Mr. HENRY EDMUND BLACKBURNE DANIELL, Mining Student, 8, Ashfield Terrace, Ryton, S.O., County Durham.

Mr. ROBERT CLARK THOMAS, Mining Student, Houghton Colliery, Houghton-le-Spring, S.O., County Durham.

Mr. J. H. MERIVALE delivered the following "Presidential Address":—

PRESIDENTIAL ADDRESS.

By J. H. MERIVALE.

I thank you for having elected me for a second year of office as your President; and also for the support that you have given to me at these meetings by reading and discussing the papers. Many of these papers are of much interest, and a list of them has been laid before you in the annual report of the Council.

The only matter of importance that has occurred during my first year of office has been the placing upon the walls of this theatre of many of the portraits of past-presidents of the Institute. This it was decided by the Council should be done some years ago, and the panels to hold the portraits were put in place. Twelve of these panels have now been filled; and I have reason to believe that the rest of the portraits will be presented and hung before the termination of my second year of office. It is an interesting record, and one which will become more and more interesting as years roll on.

"The proper study of mankind is Man"; and, whilst considering what would be a suitable subject upon which to address you, it was forced upon me that this very important factor in the success of our industry, Man, had been somewhat neglected.

Some of my predecessors, who had made some one branch of the science of mining their own, had, out of the fullness of their knowledge, given us much interesting and valuable information upon it, whilst others had given us a luminous résumé of the advancements recently made in mining at the time of their taking office. But no one appeared to have taken Man as the subject of his discourse.

Great strides have been made in the introduction of new and improved machinery since the birth of this Institute in 1852. Have there also been improvements in the men required to guide these machines, without whom the full benefit of their introduction cannot be obtained?

Important as is the mechanical side of our profession, the human side is, in my opinion, of still greater importance. The best tools will be of no avail, without intelligent workmen trained to use them, and highly educated managers capable of directing these workmen and of designing new and improved machinery fit to cope with fresh difficulties arising from the changing conditions of our industry. The importance of the character of "the man behind the gun" is proverbial, and the character of the man at the machine is equally important.

I had proposed to consider this subject, Man—both the engineer and the workman—under various heads, such as amusements, capital and labour, efficiency, health, thrift, etc. But I soon found that the subject was far too vast to be compressed within the limits of a Presidential address. I have therefore confined myself to the workman only, and considered the changes that have occurred during the last 50 or 60 years in his amusements and in his relations with capital.

His Amusements.*

The amusements of our workmen may appear rather a frivolous subject to be included in a Presidential address. But, with an eight hours' day almost an accomplished fact, one of the avowed objects of which is to give them more leisure, it is evident that the nation considers the question of recreation a matter of some importance: and it appears to me that the question of how the miner will use this spare time is of very practical interest to the coal-trade.

It is a task of no little difficulty to look back over half a century, and recollect the principal methods of amusement which found favour in Durham and Northumberland in those days. The sporting centre of the north was then, as now, Newcastle, and the athletic events which brought the sturdy pitman into the city at that time may be taken as a reflection of the contests of less importance in his own village, in which he took, or had taken in younger days, a personal share. For it was the best of sport that was visible in Newcastle, the minor lights staying to wrestle on the village-green or to quoit upon a space of ground situated in convenient proximity to the village

* I have to thank Mr. J. F. Petrie for a great deal of information upon this subject, and take this opportunity of doing so.

hostelry; while those of greater skill came to "the toon" to try conclusions for championships, to win or lose large stakes for themselves and more momentous wagers for their admiring friends. Horse-racing was the sport *par excellence*, though hardly, by reason of its infrequency, to be called the most important. Bowling, not the peaceful pastime of the quiet lawn, but the more strenuous game in which stalwarts (stripped to what the local phrase designates "linings") hurl heavy "pot-shares," varying from 5 to 50 ounces in weight, was distinctly one of the most popular pastimes of half a century ago. From many points of view it is to be admired as a form of sport. Simple though its rules may be, it requires no small skill: for a man who desires to excel must be able to throw his bowl not merely over a long distance, but with an accuracy which will assure its alighting upon a favourable spot and avoiding rough ground which might retard its progress. It is a vigorous exercise in itself, and it has the additional advantage of taking its devotees away from surroundings which offer many temptations to the man with a light heart and a full pocket. The town moor had always been the main centre of bowling, but many famous matches were brought off on the sands at Newbiggin, Shields, Blyth and Castle Eden; and there were not a few inland courses where the pitmen gathered to throw their bowls, and to "back" their fancy with a perhaps more than judicious portion of their hard-earned pay. It is worthy of remark that bowling, which had almost died out in the intervening years, has suddenly seen a great revival; and I am told that it is not at all uncommon for five or six thousand spectators to assemble on Newcastle moor when two recognized experts are trying conclusions for a substantial stake.

Natural causes had much to do with the immense vogue of rowing in the fifties amongst the working-class population. The keelmen had in their ranks many keen oarsmen, and the banks of the river Tyne afforded innumerable points of vantage for watching both the practices and the contests themselves. Thus, with circumstances providing many performers and supplying their audiences with every convenience, it is not difficult to see why rowing should have attained a prominent place in north-country sports. It was not only on Tyneside that rowing had

its hold. The other local rivers all contributed their quota to the men who were the outstanding figures of the fifties, when the contests decided on the Tyne occupied the attention of all the world. Clasper, Chambers and Winship were the prominent personalities then, and they were followed by many others of little less renown.

No sport of all those that appealed to the affections of north-countrymen has fallen upon more evil days than this. There is now no professional rowing worth the name, and the time-honoured Christmas handicap is, I believe, only kept alive with difficulty and arouses an infinitesimal interest. There are many causes for the change. It is charitable to place first amongst them the increase of traffic on the river and the building-up of its banks. On the other hand, the symptoms of decay undoubtedly manifested themselves before either of these things had affected the sport. And the reason is equally obvious and infinitely more unpleasant.

The sport died a natural death. A matter to me of great regret, as I have always taken a great interest in rowing; and many of the pleasantest evenings of my residence in Newcastle in the early seventies were spent upon the Tyne, not only as a competitor in some of the minor contests, in which I was not unsuccessful, but in the encouragement of this sport at the Durham University colleges.

It is not likely nowadays to be revived, and its memory only remains with the older generation as one of the great features of the recreation of the toilers of the north in the "good old days."

Horse-racing has always been popular, and meetings have been held in several centres in the mining districts: such as Amble, Blaydon, Boldon flats, Durham, and Houghton-le-Spring for very many years. Newcastle races, however, when they were held upon the town moor, formed the biggest sporting event of the year. Nowadays they are not so intrinsically important as races. They serve for the mass of the population as an excuse for the annual holiday, and the gathering at Gosforth Park is only an incident in a general exodus. But in those days the races were the centre of attraction, and the town moor was the Mecca of every northern pilgrim. They were more robust days, and the concourse might have been rougher, perhaps less decorous, but there

is no denying that the spirit of enjoyment was more general and keener. The local feeling, too, was greater. The miners were—and are still—to a greater extent than any other body of workers averse to patronizing a sport which they could not see. They liked to see the horses that they had backed run for their money, and they were lifted into ineffable realms of delight when a north-country horse brought the Northumberland Plate to a north-country owner—especially if its victory also enabled them to celebrate the holiday more lavishly. It was in 1852, "Stilton's year," the date of our foundation, that the Northumberland Plate was first run for straight out, and the system of heats abolished; and it was in that year that the actual period of racing was confined to three days only. The festival proper, however, lasted for the full week, and during that period the town was invaded from all the colliery districts. Temporary licenses granted to the publicans caused a town of canvas-tents to spring up, and the day-refectories became night-shelters for many of the enthusiasts who had arrived with the firm determination of "making a week of it"—a determination, it may be added, which was unfalteringly and completely fulfilled. Shows of all descriptions, neither better nor worse it may be believed than those which to-day accompany the Temperance Festival, added to the show of canvas and multitudes of carriages, from the four-in-hand of the peer to the pony-trap of the publican, stretched in long lines on either side of the course. Racing, indeed, whilst it lasted dwarfed all other sports; and only at such great centres as York and Doncaster, where the contests were carried out on public spaces, were like spectacles of wild excitement and whole-hearted gaiety to be witnessed. The interest in horse-racing fifty years ago was not, it is to be believed, the same kind of interest as it is to-day.

It was certainly the only sport to which the press devoted any attention, small and often contemptuous paragraphs sufficing to cover the quoiting, the whippet running, the pigeon flying, and the wrestling. The publication of the results, however, was neither so prompt nor so important as to-day, and was not intended for the edification of the working classes, keen as was the interest and heavy as was the wagering by workmen. At Newcastle and at minor race-meetings in this district it was, generally speaking, of a more intermittent character and confined

very largely to the meetings themselves. It was only with the increased facilities for travel provided by improved railway-communication and the contemporary improvement of the telegraphic services of the press that the custom has grown of wagering on horses that have never been and never will be seen by their backers; and that the shop-boy has come to hazard his half-crown with the same assurance as the "Jubilee Plunger" threw away his thousands.

Special mention also should be made of wrestling, which if it never was, as in Cumberland and Westmorland and in some portions of the Lancashire coal-field, the paramount pastime, at any rate absorbed a great deal of attention, and always found a not unimportant place in the local athletic gatherings. In Newcastle fifty years ago there existed a wrestling green, near the old shot-tower, where many of the northern champions were seen; but that has long since passed away, and the fine old sport does not occupy much of the time and training of the athletes of to-day. Possibly the causes which contributed to the decay of rowing had a little to do with the decline in wrestling, as they certainly are responsible for the lowly place that boxing now occupies in the popular esteem. It is a great pity, for a finer pastime than the old style of wrestling, combining the need for courage, skill, endurance and self-control it would pass the wit of man to devise. Of the minor sports, whippet racing, pigeon and sparrow shooting and pigeon flying show the least changes, for they have always had, as they have to-day, a considerable number of followers. Rabbit coursing, I am pleased to note, is less popular than it used to be. Running appears to be going out of favour; and trippet and quoit or buck-stick, a favourite game some forty years ago, has disappeared altogether. Cricket, elsewhere the king of summer games, has never strongly appealed to the miner, who likes something a little more exciting and more easily comprehensible. Bathing also has never been popular. Probably because we seldom have here, on the north-east coast, a spell of really hot weather.

To-day, football, unknown amongst the miners five-and-twenty years ago, is the game which holds the greatest sway, and, whether for good or for ill, the district between the Tweed and the

Tees has caught the infection in a very pronounced degree. As played at present, in spite of the professional element, the game is kept, I believe, above suspicion for the most part: but, as it has become one of the great instruments of gambling, it is hardly to be supposed that it will long remain free from the canker which killed the once equally popular sport of rowing.

One of the most interesting examples of the growth in popularity of a particular sport is to be found in rifle shooting. The rifle is the legitimate and direct successor of the bow and arrow, a weapon which for certain purposes, principally social, is not yet entirely obsolete. Archery, however, has never been very popular in the north country, although there was once a flourishing club in Newcastle, and it may be said to be a thing of the past up here. But, as Regent's Park bears annual witness, it still has its devotees in the south. Rifle shooting on the other hand has found continuous favour since the inception of the volunteer movement; but the perfection of the modern weapon and the wave of patriotism which swept over the country during the South African war gave it an immense impetus. It is a matter for congratulation that the movement in favour of rifle shooting should have proved to be of a permanent character and to be so popular at many of our collieries, for, even from the purely sporting point of view, it is a pastime which possesses infinite attractions. It demands a keen eye, a steady hand, and an abundance of nerve, and if any real proficiency is to be attained it needs also much time spent on the open-air ranges. These essentials of the marksman are not to be obtained without considerable self-sacrifice and self-control. Lord Roberts, who has done so many fine things for his country, deserves its gratitude for the unceasing efforts that he has made of recent years to arouse an interest in rifle shooting, and it is very largely owing to his exertions that the civilian movement has reached its present large proportions. Locally, the enthusiasm for this branch of sport has been fostered by the endeavours of *The Newcastle Chronicle*, which, after being amongst the first business houses to establish a rifle club for its workpeople, has offered each year a valuable silver cup and a substantial sum in prize money open to competition by all comers. Since its establishment, six years ago, the meeting at which the cup is shot for has grown in

importance, until now it is the second largest in the United Kingdom, the national meeting at Bisley alone exceeding it in size. Over five hundred marksmen, regulars, volunteers and civilians were seen at the range this year when the trophy was shot for, and there can be no doubt that the gathering has had a most stimulating effect upon the growth of the rifle movement.

Fifty years ago cock-fighting was a popular pastime, and great were the rivalries between the various strains of birds. The time when the sport was at its height was on the morning of race-days, and there were various cock-pits in Gallowgate, where the miners used to assemble in crowds to see the mains. Modern feeling, however, is altogether opposed to a game which, whether inhuman or not, is certainly as unedifying as it is exciting. It is prohibited by law, of course; but there are a good many things prohibited by law which have not altogether been driven out of existence by legislative interference, and from what I have heard, I believe that if one were "in the know" it would not be an impossible task to buy a pair of silver spurs to-day and to see them used. It is, indeed, only a few months since we read in the newspapers of a successful prosecution of men for participating in an organised cocking main and it is not to be supposed that this solitary conviction bears any due proportion to the number of contests which do not officially attract the notice of the police. Though there still is some cock-fighting it may, however, be taken that its extent is infinitesimal compared with that of half a century ago, and there will be found few people to lament its decline.

Instrumental music is, and has always been, very popular. There are but few collieries that have not a brass band, often a very good one: Hebburn for example. But choirs are almost, if not entirely, non-existent. I started vocal societies at two collieries, in Durham, early in the seventies, which flourished for a time and gave much pleasure to the members, both men and women, if to no one else. But so soon as I left the neighbourhood, they ceased to exist. The reason I believe to be climatic; but space will not permit of my going into this question.

Golf and tennis have not yet come into vogue; but I can see the faint beginnings of these pastimes, and I venture to

prophesy that both games will become popular, amongst miners, within twenty years.

Of other amusements, such as pitch-and-toss, gardening, bee and poultry keeping, dancing, institutes and clubs with their reading, games and billiard-rooms, boating and rowing on sea and river, space will not permit of any detailed mention. But there is one sport which has lately come to the front, and is worthy of notice as being the only form of out-door amusement participated in by both sexes. I allude to bicycling. Five-and-thirty years ago, I doubt if there were more than half-a-dozen bicycles in the North of England. Of these I had one, my brother another. It was some years after this, before they spread into the colliery villages, and not until quite recently that the wives and daughters of the miners participated in the amusement.

An unamiable feature in the character of the miner, and I am afraid in that of other members of the working classes—I see that Lady Bell in her book, *At the Works*, notices it also—is that he does not consider his women-folk when catering for amusement. The young women amongst the miners do not, as a rule, go out to work. They can, therefore, earn no money for themselves, and are dependent upon their fathers and brothers. Until bicycling was introduced, their need for recreation was not considered in any way; except for dances, and an occasional picnic where their presence was required in the interests of the other sex. I am afraid that this, too, may be at the bottom of their being indulged with bicycles; the men find it rather dull to ride alone; and still more dull to ride in company with a young woman on foot.

It is a great pity that, in this matter of recreation, the interests of the other sex are not more considered by the working classes. It seems to me that nothing but good to both would result. Only last week, in looking over a workmen's institute in a colliery village and finding it in the untidy and dirty condition with which those who are in the habit of visiting these institutions are only too familiar, the thought struck me that if the women were members as well as the men what a scrubbing and cleaning there would be, and how much more cheerful, pleasanter and sweeter would the rooms be made to look. And

why should they not be members? At that great institution housed under the same roof with ourselves, of which Newcastle-upon-Tyne is so justly proud, women are equally eligible with men for every privilege of membership; and the rooms, lectures, books, management, etc., are shared in equally by both sexes. It is some years now since the middle classes awakened to "the rights of women" in this respect. I hope I may see in the introduction of bicycling for women into the colliery districts that this awakening is spreading to the miners also. It is a distinct step in advance, as is also the dying-out of such cruel sports as cock-fighting and rabbit-coursing.

It is interesting to make a comparison between the space afforded in the newspapers to popular sports at the period when this Institute commenced its work and to-day. Such a comparison can only be of an approximate character, and it may be as well to make it by taking the pages of *The Newcastle Chronicle*. *The Newcastle Chronicle* was first published as a daily newspaper in 1858. It was a small paper, with four pages each of six columns; and it used to give on an average about one column each day to sport, the news being confined chiefly to horse-racing; whilst, as a special condescension, there was the result of a boat race or wrestling match of more than average importance, and possibly the bare scores of a cricket match of the first class. To-day the paper will give from eight to twelve columns of sport, the news embracing games and recreations of every sort, from a rabbit running to a Derby, and from a boxing bout between obscure pugilists to a test match. And in that time, roughly speaking, the population of the two counties has risen—the figures are those of the nearest census years—from 993,856 to 1,790,188, or almost double in the fifty years. If we take it, then, that the space given to sport is now ten times what it was when the newspaper started, and remember that the newspaper is now three times as large as it was then, we find that it devotes, comparatively speaking, a little over three times as much space to sporting news as it did fifty years ago; so, if we take into account the doubling of the population, there is still reason to presume that the public interest in sport, as reflected in the attention devoted to it by the press, has increased rather than diminished.

His Relations with Capital.

When our Institute was founded, fifty-five years ago, there were no trade organizations for the fixing of wages and other terms of employment, such as we have at present. Unsuccessful attempts had been made from time to time by the miners of the two northern counties to unite themselves together for the purpose of obtaining better terms from their employers, and also for the passing of Acts of Parliament to better their condition. These attempts, however, did not meet with much success, and their failure appears to have been due not so much to the strength of the masters, as to internal dissensions amongst the miners themselves. Anyone reading the history of this, and other movements amongst miners, cannot but be struck by their want of confidence in their leaders, a want of confidence which is almost as apparent now as it was sixty years ago, and is the despair of their well-wishers.

According to Mr. Richard Fynes, the first attempt to form a union was made in 1809; and, although several unions were formed and broken up during the succeeding fifty years, it was not until 1865, when the attempt to combine the two counties together was finally abandoned, that the present associations (as we now know them) were formed. In that year, at the suggestion of Mr. Thomas Burt, Northumberland seceded from the union of the two counties and formed the present Northumberland Miners' Mutual Confidence Association, to be followed, a few years afterwards, in November, 1869, by the formation of the Durham Miners' Association. It is very largely due to the ability and devotion of two men, Mr. Thomas Burt and Mr. William Crawford, that both these institutions have been more fortunate than their predecessors.

The coal-owners appear to have been combined together from, at any rate, the early fifties; but the Northumberland and Durham Coal Owners' Associations, as now constituted, were not formed until 1867 and 1872 respectively.

Prior to these dates disputes were usually settled by hard fighting, as has sometimes been the case since. But, although regrettable incidents have occasionally occurred, it can be said to the credit of the North of England that never have such scenes been enacted as disgraced labour disputes in Manchester and Sheffield during the fifties and sixties: and are disgracing parts of America, even to the present day.

Since these dates, the above associations have represented the coal-trade of the North of England in fact as well as in name. And when, as has occasionally happened both in Northumberland and in Durham, the men have not been guided by their representatives upon these bodies they have had cause to regret their want of confidence. Other movements, too, took their rise in the sixties which have had a very important influence, an influence for good, upon the miners of our northern counties.

In 1861, the first co-operative store was established at West Cramlington, from which have radiated stores into all the colliery villages.

In 1862, the Miners' Permanent Relief Fund was instituted, an outcome of the Hartley accident of January in the same year. At the first annual meeting, held in May, 1863, it was announced that about 8,000 persons had joined the association. In spite of the Compensation Act of 1897, which many people thought would have injured the fund, it has gone on growing steadily from year to year, until at the last audit in December, 1906, the membership was 165,981; the income, £177,249; and the accumulated funds £398,201.

The establishment of science-and-art classes, and the lectures of Mr. William Rowden in the colliery villages of Northumberland and Durham, all took their rise about this time, and have been of great value. Not only in giving information upon many useful and interesting topics, but in educating the miners in the true meaning of education, strengthening their minds, broadening their views, and teaching independence of character, and preparing the way for the next stage in the industrial development of the coal-trade of our northern counties, namely:—The discussion of trade questions between masters and men upon an equal footing, the recognition of the fact that labour is interested in the coal-trade equally with capital, and that if capital, as responsible for the proper working of the mines, must be permitted to work them in its own way (so long, of course, as it conforms with the various Acts of Parliament regulating the industry), labour is entitled to have a voice in deciding upon what conditions as to wages and hours of work it will consent to be employed.

Acting upon these lines, the Durham Joint Committee was established in April, 1872; and the Northumberland Joint Com-

mittee in February, 1873. Of the original members of these committees, twenty-four in number, though I am happy to say there are several still living, only one active member, Mr. J. B. Simpson, is left. The functions of these committees are to settle local disputes, within the rules of the associations, questions affecting these rules being settled by the associations themselves. During the thirty-three years of their existence, the joint committees have amicably settled thousands of disputes, many of which would otherwise have resulted in stoppages of work; and it is very rare, if ever, that their decisions have not been loyally accepted by both sides.

But the court, which it appears to me should be the final court of appeal, is becoming more and more a court of first instance; and its time is wasted over trumpery disputes that ought to have been settled at home. The result is congestion; and really important cases, causing much friction at the collieries, cannot be heard until several months after they have arisen. The fact that the responsibility of coming to a decision can be put upon the joint committee seems to have taken the backbone out of the representatives of both parties at the collieries; and they are no longer capable of assuming responsibility themselves.

The joint committee, like the telephone, has great advantages. But both have, to my mind, a very serious, and, I am afraid, far-reaching defect: that they destroy individual initiative and sense of responsibility; and so in time must weaken the moral fibre of the nation. At one time, when a man was in a difficulty he was obliged to worry through by himself, and did so. Certainly this was to his own benefit and in the majority of cases to the benefit of his employer, whether that employer was the owner of some industrial undertaking or the State itself, as the man upon the spot is usually best able to judge what ought to be done, and is in a position to act promptly. But now he runs off to the telephone, or joint committee, and throws the responsibility upon someone else.

Various schemes have been adopted for mutually settling rates of wages and other matters outside the powers of the joint committee, without recourse to strikes and lock-outs. Discussion across the table at meetings of the associations of masters and men was a great improvement upon former methods, but

not altogether satisfactory, as, in the event of disagreement, there was no way, short of arbitration (a tedious process), of amicably settling the point of difference.

In spite, however, of this objection to arbitration, several important differences were determined in this way during the years 1874 to 1877; and it was as the outcome of these arbitrations that the method of settling wages disputes by a sliding scale, based upon selling prices, was adopted. If not evident before, it became evident in the course of these arbitrations that wages were very largely a question of selling prices, and this point was emphasized by the late Lord Herschell, amongst others, in one of the awards. It was suggested that wages might rise and fall with the rise and fall of selling prices, and so automatically settle wages, the only difficulty being to determine the relation that should be maintained between these two factors. After considerable negotiation, a sliding scale was agreed to in Durham in March, 1877, followed by one in Northumberland in November, 1879. By these scales, modified from time to time, wages were regulated in the two counties for about twelve years. But it became evident that other factors, besides selling prices, must be taken into account; or that the relation between wages and selling prices, that had been agreed to, was not a reasonable one. Be this as it may, the sliding scales for automatically regulating wages were abandoned in both counties; and the present arrangement, namely, a conciliation board with an independent chairman, whose decision should be final in default of agreement between the two bodies, was established in Durham in 1893, and in Northumberland in July, 1894. The conciliation boards, although mainly guided by selling prices, can, and do, take other factors into account.

The above methods of settling industrial disputes are none of them perhaps perfect, but under their guidance there has not been a general strike in Durham for over fifteen years and in Northumberland for more than twenty years. They are, I believe, the best methods possible at the stage that we have now reached in industrial evolution, and cannot be improved, except in detail, until a further stage is reached, when the identity of the interests of capital and labour being recognized by everybody, as they are now by the few, disputes between labour and capital will become impossible.

And here, to digress for a moment, people appear to me to be apt to forget that circumstances alter cases, and looking down from the elevated plane that we have now reached in social development (a plane which will in its turn be looked down upon a few generations hence) are inclined to find fault with the actions and mode of life of their forefathers; oblivious of the fact that they had not reached the stage of civilization when our present methods would have been possible, or perhaps even desirable. To take a very extreme case, slavery, which everyone now rightly condemns, was probably both necessary and desirable at one period of the world's history. Much as we may approve of our present methods of settling disputes, and superior as they may be to those in vogue at the birth of our Institute, each was probably suited to the times in which it was practised, and a conciliation board would have been as impossible in 1850 as the arrangement that will come into force in 1950, whatever it may be, would be impossible now.

There is no standing still. Change there always has been and always will be whilst this world lasts, in one direction or another; sometimes for the better, sometimes for the worse; on the whole, I hope and believe for the better, though we have had, no doubt, temporary set-backs from time to time. It will be interesting and useful to consider the direction along which we are likely to travel in the future. One or other of two paths we shall, I believe, follow, the one leading towards socialism: the ownership and exploitation of the mines by the State. The other towards co-operation: the ownership and exploitation of the mines by the workmen engaged in them. The first, I believe, would lead to disaster, the last to the advantage of capital and labour alike, and through them to the country generally.

Socialism has been a good deal before us during the last few years. By this I mean that it has been a good deal talked and written about. Not that we are any nearer to a purely socialistic State at the present time than we have ever been. To quote Mr. W. H. Mallock "Such a State has never existed, and there is no reason to suppose that it ever will."* But attempts may be made to found such a State; and as these attempts, if

* *The Times*, October 4th, 1906, page 10.

ever made, must, in my opinion, end in disaster, any tendency towards socialism in the relations of masters and men is to be avoided.

With the object of socialism, the betterment of the condition of the people, we are all in sympathy. It is as to the means that should be adopted for the achievement of this result that thinkers differ; and I believe that the object which the socialist thinks, rightly or wrongly, can be obtained through the State, can be obtained, and obtained much more satisfactorily, by co-operation. It is therefore in the direction of co-operation that I look for my ideal in the future organization of our industrial system.

The working-man, however, has hardly yet reached the stage in social evolution that would enable him to conduct successfully colliery enterprises. No one can read his letters and speeches in the press without realizing his ignorance of the elements of political economy as applied to coal-mining, to commerce, and to business generally. It is evident that there is a very prevalent belief amongst the miners as a body that—to quote one of their leaders and a county councillor—"In future, wages should not be ruled by prices, but prices should be ruled by wages"; and, until miners realize that this is impossible, it will be hopeless for them to undertake to run a colliery of their own. But this general dissatisfaction with prices as a basis for wages and the exaggerated idea of the large profits made in coal-mining will probably lead to profits, instead of prices, being adopted as the next step for a basis in determining wages.

The difficulties in the working of coal have increased so much of late years, that the efficiency of the miner has decreased; and a relation of wages to selling prices that the coal-owner could afford to agree to twenty years ago, he can agree to no longer. It is only due to the fact that selling prices have kept up at a higher average during the last eighteen years than they did when the various sliding scales were established, and that these sliding scales were more favourable to the masters in their higher, than in their lower reaches, that they have continued for so long the main factor in settling the rate of wages. Just as the present plan has had an educative value in giving the miner a knowledge of prices, so will an agreement based upon profits have an educative value in giving him a knowledge of the profits

that are made in the coal-trade. It will show how erroneous is the prevalent idea of very high profits; but, at the same time, it will show that, taking one year with another, reasonable profits can be made. And, with the knowledge that the miner has of the losses due to matters within his own control: such as excessive supervision, idle time, careless making of places, dirty coal, etc., losses which we may hope would not be allowed to take place in a colliery owned by the persons employed in it, and where each workman was interested, not only in himself doing his very best, but in seeing that his brother workmen did their best also; large economies could be effected, and consequently larger profits earned.

There are, however, other points besides political economy and commerce upon which the miners as a body require further training before they can hope to manage a colliery successfully; and a very important one, is that they must learn to put more confidence in their leaders. There appears to be among the miners of Northumberland and Durham, an inherent distrust of those in authority over them: whether they be put over them by circumstances over which they have no control, as are the agents and managers of the collieries; or whether they be their own chosen leaders. An essential for the success of any industrial undertaking, and more particularly for one like a colliery, where there must necessarily be very large variations in profits, is that it must be under the control of a thoroughly capable man who has the confidence of his employers, and consequently a practically free hand to do what he knows to be right. This confidence I am afraid, during bad times at any rate, would be withheld from the agent of a miners' co-operative colliery. His hands would be tied, and the undertaking would inevitably come to grief.

I do believe that a co-operative colliery *could* tide over a few years of bad trade. From a careful examination of the results of trading during bad years I find that, at any rate, the receipts would be sufficient to pay a so-called "living wage"; and so long as the men got this they could wait for the prosperous years for high wages and for interest upon their capital. Moreover, after a few years, a reserve fund would have been set aside sufficient to pay good wages and interest on capital during

the bad years. It is, of course, another question whether a co-operative colliery *would* tide over the bad years. I am inclined to think that at the present time it would not.

Another difficulty that is sometimes mentioned in the way of co-operative collieries is the want of capital amongst working miners. This, if it exists, is in my opinion due, not to want of opportunity, but to the want of a little self-denial on the part of our young men. The capital required to start a colliery, of course, is a variable amount, depending upon the circumstances of each case, but it may be taken roughly at 10s. per ton of annual output or £150 per hand employed. And the question is, can such a sum as this be raised by the workmen? There cannot, in my opinion, be any doubt upon this point. If the miner could be persuaded to do what the middle classes do, namely, postpone marriage until seven or eight and twenty, instead of marrying soon after he comes of age, there would be no difficulty in the matter. Moreover, the girls would marry later in life. The lassie of eighteen, who appeals to the lad of one-and-twenty, would not satisfy the young man of twenty-seven or twenty-eight, and the delay upon the part of the girl in undertaking the responsibilities of matrimony for four or five years would give her the opportunity of learning some of the duties of a wife and mother; and also of acquiring more physical strength, without which, however willing and capable a woman may be, these duties cannot be carried out either with comfort to herself or to the physical well-being of her descendants.

A miner makes as much money at four- or five-and-twenty as he does at any time of his life; and the support of a wife and four or five young children can be fairly put at about 20s. a week. In other words, if the married miner of five-and-thirty can support a wife and family, the unmarried miner of five-and-twenty can save 20s. a week. By the time therefore that he was seven-and-twenty he could have saved £300, and other classes of labour a smaller sum in proportion. It would not be necessary, moreover, that the whole of the capital should be held by the workmen interested in a colliery; some could, and no doubt would be supplied, as at present, by the general public.

It is also evident from the large sums that miners have already saved and invested in various undertakings, that want of capital would be no bar to the establishment of co-operative

collieries; and in their unions, building societies, savings banks, benefit societies, relief funds and co-operative stores, they already have vast sums invested. This fact, I think, will make them very shy of socialism, when socialism is no longer academic, but becomes a question of practical politics. In distributive co-operative societies alone I estimate that the miners of Northumberland and Durham have £2,000,000 invested. These took their rise in the North of England in 1861 at West Cramlington. Mr. R. Fynes gives a very graphic account of the commencement of the undertaking, too long to quote here, but it was a success from the very first. At the end of the first quarter, goods to the value of £449 14s. 2½d. were sold, and the spread of the movement is shown by the fact that during the quarter ending on February 2nd, 1907, the Cramlington District Co-operative Society, Limited, sold goods to the value of £47,973 0s. 1d.

Productive co-operation, however, in which for the moment we are interested, has not been a success, so far as mines are concerned. The nearest approach to success being found, I think, in the "tut-work," a species of productive co-operation, still in vogue in Cornish mines. Every attempt to start and run a co-operative colliery so far has been a miserable failure. Of these attempts there have been several.

Using the term "co-operative colliery" in its most extended sense, that is, including all those in which the workmen were paid something over the current rate of wages in the form, for example, of a percentage upon the profits; as well as those in which they were themselves the owners of the colliery, the following examples have come under my notice.

The first attempt, so far as I know, to work a colliery upon co-operative lines was made by Messrs. Briggs in 1865, when the firm became a limited liability company. It was stated that "everything was taken at the value at which it stood in the books of the firm; while two-thirds of the capital, and the full control of the practical management were to remain in Messrs. Briggs' hands. . . . . The allocation of profits was as follows: whenever, after providing for the redemption of capital, etc., the divisible profits exceeded 10 per cent. per annum on the capital of the company, the workpeople, including managers or agents,

at fixed salaries, were to receive one-half of such excess profits to be distributed amongst them in proportion to, and as a percentage upon their respective earnings during the year. The company was, at this time, paying about £1,000 a week in wages." For ten years this arrangement appears to have worked satisfactorily, the dividends to the shareholders varying from 13½ to 25 per cent. (during the two years preceding the arrangement they had averaged 4½ per cent. only, with, of course, no payments of bonus) and the yearly bonus to the men from £1,740 to £14,256; and, in addition, Whitwell Main colliery was bought, mainly out of profits, and large sums were allocated to depreciation and reserve funds.

During the last half of 1874, however, trade fell off, and in 1875 the men throughout the district were required to submit to a reduction of wages. After a strike of four weeks, in which Messrs. Briggs' workmen joined, the matter was referred to arbitration, and a reduction was awarded by the umpire. In consequence of the men taking part in this strike, the bonus system was abandoned in February, 1875, and thus ended, so far as I know, the only attempt at a co-operative colliery that has had any measure of success.

Several other attempts to work a colliery on co-operative lines have been tried. In 1866, the South Buckley Coal and Fire-brick Company, Limited, was registered; shares were taken, amongst others, by Mr. Thomas Hughes, the Marquis of Ripon, the Earl of Derby and the Duke of Devonshire, and of a capital of £50,000, £10,000 was to be reserved to the workmen. This company failed very soon after its inception.

In 1872, the Darwen Mining Company, Limited, with a nominal capital of £12,000 was floated by some members of the Darwen Industrial Society. A colliery, opened at Whitebirk, near Blackburn, was worked for a time, but it did not pay. The company went into liquidation in 1882, and the colliery was taken over by the Darwen Industrial Society who were large creditors. The society continued to work the colliery until 1889 with a fair amount of success, when the pit was closed and the plant sold.

The Co-operative Mining Society, Limited, in which the miners of the North of England were large investors, was registered on January 8th, 1873. "The shares were transferable

and of the value of £5 each. They were to have a first claim upon the profits equal to 10 per cent. per annum. After this claim was satisfied, a portion of the profits were to be devoted to the reserve fund and the remainder was to be divided equally between labour, capital and trade." The movement was very generally supported by the miners of Northumberland and Durham, 2,163 shareholders joined with a paid-up share capital of £35,796; and Monkwood colliery, near Chesterfield, was bought for £68,000 in April, 1874. The undertaking, however, failed, and the company was wound up in 1877, the shareholders losing the whole of their capital. Into the causes of the failure I do not propose to enter, except to point out that, purchased at a period of inflation, too much, no doubt, was paid for the colliery; and although it was nominally co-operative and enthusiastically supported by the miners of Northumberland and Durham, the Monkwood workmen declined to become shareholders in it.

In addition to the companies mentioned above, the following were floated during the seventies:—The Eccleshill Coal Company, Limited, registered in April, 1872. The Leeds and Yorkshire Co-operative Coal-Mining Company, Limited, registered at the end of 1872. It was better known, perhaps, under the name of the Lofthouse Colliery, Limited, which is no longer co-operative. The Leeds, Morley and District Co-operative Coal Society, registered on December 28th, 1872. The Alston Co-operative Coal Company, in March, 1873. The Ayrshire Coal Mining Society, in October, 1873. The Scottish Co-operative Coal Company, Limited, in 1873. The South Yorkshire Mining Co-operative Society, registered on July 21st, 1873. The Tipton Green Colliery Company, Limited, started in 1873, and the Leeds Co-operative Society invested £19,000 in it The Broughton Moor Co-operative Mining Society, registered on January 20th, 1874. The United Coal-mining Society, registered on January 26th, 1874. The West Yorkshire and North Staffordshire Co-operative Coal-mining and Building Society, registered on April 22nd, 1874. The Shirland colliery was purchased by the South Yorkshire and North Derbyshire Miners' Association early in 1875 for £69,000. The Derbyshire and Nottinghamshire Co-operative Mining Society, registered on February 13th, 1875. The Spring Vale Colliery Company was taken over by the Wholesale Co-operative Society, Limited, in 1880. Very few of these

companies had more than two or three years' existence, and every one failed as a co-operative colliery. The history of their misfortunes may be read in the *Co-operative News*, and a very excellent résumé by Mr. Benjamin Jones.*

After such a record of failures it seems hopeless at first sight to look to the establishment of co-operative collieries in the near future as the next step in advance, in industrial organization. But a little reflection and a consideration of the circumstances under which these collieries were floated will go some way to dissipate this conclusion. With the exception of Messrs. Briggs, and the South Buckley Company, all these undertakings were started during the years 1872 to 1874, a period of inflation, the very worst time for commencing a colliery, even upon recognized wellknown lines, and utterly impracticable when the colliery must necessarily be of an experimental and tentative character. There is not, of course, this excuse for the failure at Messrs. Briggs' colliery. It is forty years ago now since it was started, and thirty years since it failed as a co-operative concern, and at this distance of time, with but meagre information at my disposal, it is impossible to say exactly why it failed and if failure was inevitable. But both masters and men have learned a great deal since 1875; and I do not think that a North of England colliery at any rate, that had been carried on successfully for ten years on the bonus system, would be abandoned now-a-days. To begin with, the immediate cause of its failure was a general strike, and this we have not had in the North of England for fifteen years. In addition to the unfortunate time selected for the launching of these schemes, not one of them appears to have been really co-operative, that is, collieries in which the workmen engaged at the mine themselves owned, if not all, a considerable proportion of the capital; though this was no doubt the intention of the promoters in most cases.

To quote the prospects of the Co-operative Mining Society, Limited, floated by Mr. Thomas Burt, Dr. Rutherford, Mr. W. Morrison, Mr. E. Lowther and others:—"But what is wanted is, that the miner shall feel that the pit in which he works is his own; and, in order to do this, it must be open to him, if he chooses to invest all his earnings there. To this end, the miners of Northumberland and Durham have resolved to have collieries

* *Co-operative Production*, 1894, vol. ii., pages 444 to 539.

of their own. . . . It is intended that every worker shall be a member, etc." Unfortunately, I consider, this did not turn out to be the case in practice. The miners of Northumberland and Durham became shareholders, and put their money into the Monkwood colliery; but I understand that not one of the workmen employed at the colliery was a shareholder, though urged to become so. In the face of this, the colliery, even if it had been a success, would have been no triumph for co-operative production.

As I have already said, I do not anticipate that the miners will become the owners of the collieries in which they work for many years yet; though I do look forward to this, and not to socialism, as the final solution of the industrial problem, so far as anything can be final in this world. Great as the advances are that the miners have made since the foundation of our Institute, they require further education in commercial knowledge, in thrift, in confidence in their fellowmen, before they will be capable of carrying on with success an undertaking so uncertain as a colliery and subject to such fluctuations in value. It has been said of a North of England royalty-owner, who not only owned the coal but worked it himself, that he made half-a-million one year and half-a-crown the next; and he thought it therefore best to let his mines and be content with a smaller, but more regular income.

How best to deal with these fluctuations is the problem now, as it was 3,600 years ago. Good years have always been followed by bad years, and the seven lean kine, now as then, will devour the seven fat kine, unless means are taken to prevent them. Now as then, foresight and thrift are the only solutions of the problem. Provision must be made in the good years for the bad years that will surely follow. It is the lean years that will try co-operative collieries, and reserve-funds must be set aside during the fat years to meet this. But I am afraid that whatever hopes we may have for the future, and hopes I certainly have, in the present state of education amongst the miners, not even such a leader as Joseph himself would induce them to make so necessary a provision.

In conclusion, I thank you for the patience with which you have listened to this address—a patience which may tempt

me to inflict upon you at some future date the remaining sections that I have already mentioned and had originally intended to include in it.

Mr. J. B. Simpson, the oldest of five past-presidents present, proposed a vote of thanks to Mr. Merivale for his address. It was the only address that had been delivered during the past nine years, with one exception; and the subject was somewhat of a departure from those included in the objects of the Institute. No doubt intelligent and healthy sports would be a great advantage to the rising generation, and would have a good effect on the working of coal. The President's very able and lucid address had certainly put before the members a great field for thought.

Mr. Thos. Douglas (past-president) in seconding the vote of thanks, said that the address would stimulate the members to do more than had hitherto been done in the endeavour to promote the moral elevation of the men amongst whom their lives were spent.

The vote of thanks was cordially adopted.

Mr. J. M. Liddell (Cobalt, Canada) wrote that it would be conceded by most workmen that there were two great classes of work which must be recognized: (1) that in which all work was done by time, at definite wages; and (2) that in which work was done by the piece, under hours and at prices agreed upon; and that many sorts of work must be done by one or the other of these methods in order to get most benefit for the worker, for the investor and for the public, which was materially concerned. Now, the greatest industries were capable of consideration in this light. The military and civil services, and many manufacturers of materials required for them, fell properly into the first-class; while others such as farming, fisheries, etc., fell into the second class, and were let to private individuals or companies. In this second or contract class, the coal-producing industry naturally found its place. It had been tried for generations and in various ways, and shown to be a contract-job. The only satisfactory method for all concerned was to let contracts for the discovery, winning and working of coals for public use and for export. There was much tendency for trades unions to review and to desire to control the conditions under which such contract-

rights obtained, but they should reflect that any action which hampered the negotiation of contracts must damage all the parties concerned. Money was the blood of the industrial body, and it became feverish as risks increased: it was liable to panic when conditions of investment were upset, the body was liable to be drained white, and labour, which formed the bone and sinew, to be left helpless. The Latin fable of "the belly and its members" was still sound wisdom, and it was very much to the point to-day.

DISCUSSION ON THE EXPLOSION AT URPETH COLLIERY.*

Mr. A. L. Steavenson (Durham) said that everything at Urpeth colliery had been in the best possible order; every rule had been carried out most strictly, with the exception of that disregarded by the men who suffered in the accident; and the coroner's jury, after stating in each case the immediate cause of death, found that they were "accidentally caused by an explosion of fire-damp through shot-firing."† However, there was not one word of evidence in the report to show that any gas was present; and, on the contrary, there were repeated proofs in the report that gas was absent. The reports of the mine-officials showed that gas was not present up to 10 a.m. on the day of the explosion.‡ Mr. Atkinson stated that "gas was . present in sufficient quantity to prevent an ordinary safety-lamp being taken to the face,"§ but this was during an examination made some time after the explosion; but he added that he did "not think that Greenwell would have fired the second shot had gas been showing on his lamp."‖ He (Mr. Steavenson) specially pointed out that there was "a supply of clay for stemming shot-holes"; ¶ but "none of the stemming [used] was of the clay provided for the purpose."** This breach of the twelfth General Rule was the key to the accident; and the explosion originated in the "small coal and dust" stemming used in the shot-hole, and not in the gas nor in the explosive. The men would select the smallest

* *Report to His Majesty's Secretary of State for the Home Department on the Circumstances attending an Explosion of Fire-damp and Coal-dust which occurred at Urpeth Colliery, near Birtley, in the County of Durham, on the 17th December, 1906*, by Mr. J. B. Atkinson, M.Sc., 1907 [Cd. 3494].

† *Ibid.*, page 4. ‡ *Ibid.*, page 9. § *Ibid.*, page 10.

‖ *Ibid.*, page 14. ¶ *Ibid.*, page 10. ** *Ibid.*, page 11.

coal for insertion in the shot-hole; and the act of ramming would crush it to dust. Even with westfalite, there would always be slight flame, and that flame would ignite the dust used as stemming. He thought that the attention of miners and deputies should be specially drawn to the danger of using coal-dust for stemming. The report itself was excellent, and the facts were so marshalled that everybody could understand them; and he thought that every manager should particularly direct the attention of his officials to it.

Mr. J. G. Weeks (Bedlington) said that he was not quite satisfied that this explosion had arisen entirely from coal-dust; although the coal-dust used instead of clay in the stemming would under certain conditions of course aggravate an explosion. He would suggest, in the interests of safety, where two shots were fired in close proximity, although the place had been once examined for gas, that the place should be re-examined before the second shot was fired. It was possible, even if no gas was present when the first shot was fired, that some pent-up gas might have been set free by firing that shot, and on re-examination it might have been discovered before the second shot was fired.

Mr. Joseph Dickinson (Manchester) wrote that the facts were so lucidly given by Mr. J. B. Atkinson that any ordinary miner might draw his own conclusions, apart from those stated, as to the dangers of dust. The late Sir F. Abel's remarks* on the luminosity of flame might be traced further back. Prof. W. T. Brande† stated that if they blew any fine substance through flame in fine dust, its brightness would be proportionately increased, although the solid matter might not be inflammable, as, for instance, if they sifted a little lime or magnesia into or through it.

Mr. James Ashworth wrote that the *Report* on the Urpeth colliery explosion contained several points of considerable interest, for instance, it was probably the most direct acknowledgment, made by any inspector of mines, that "dry" coal-dust was a controlling factor in bringing an explosion to a

* *Report on the Results of Experiments made with Samples of Dust collected at Seaham Colliery*, by Prof. F. A. Abel, 1881 [C.—2923], page 9; and *Final Report of H.M. Commissioners appointed to inquire into Accidents in Mines*, 1886 [C.—4699], page 155.

† *Manual of Chemistry*, 1841, pages 223-224.

termination. Other explosions had demonstrated that watering a mine, even very efficiently, was no safeguard against the extension of an explosion, and many witnesses (including Mr. Henry Hall, H.M. inspector of mines) when giving evidence before the present Royal Commission on Mines had stated that watering in deep mines seriously damaged the roof and sides, and made them unsafe. Evidence had also been given that, if men were to work with any degree of comfort and with a due regard to health, the air of a deep mine must be dry. They were thus brought into the presence of a vital point of difference of opinion, with the non-watering advocates on one side; and, on the reverse, those who could not see any degree of safety except when watering was carried out extensively and efficiently. He (Mr. Ashworth) persistently advocated, and endeavoured to prove, by reasoning from actual facts, that watering could not protect a colliery from the extension of an explosion; that a dry mine was safer than a damp one; and that there were other risks, entirely apart from the possibility of the propagation of flame along the roadways of a mine, against which watering could have no deterrent effect—nay, it was more than probable that it materially assisted, namely, "air percussion" and "detonation." He (Mr. Ashworth) meant by these terms similar effects to those which caused simultaneous explosions at long distances apart at the Albion, Quarter, Tylorstown, Udston, Universal, and other collieries; which caused shots to be ignited and fired at a distance of more than a mile at Tylorstown, without any trace of flame being found on most part of the intervening roadway; and also at the same colliery, where a blower of fire-damp was ignited in the 8 hours dip, lower west district, Six-feet coal-seam, without any evidence of actual flame being found on the adjoining roadway.*

He (Mr. Ashworth) believed that the Urpeth explosion was a distinct exposition of the effects of detonation and air percussion, as all the necessary conditions were stated to have been present: (1) Two shots of westfalite were prepared in a heading, containing at least 2 per cent. of gas, and the safety-lamps in use were totally incapable of detecting it; and (2) the second shot was fired into an atmosphere saturated with moisture and mixed

* *Reports to the Right Honourable the Secretary of State for the Home Department*, by Mr. Robert Woodfall and Mr. J. T. Robson, 1896 [C.—8059], plan No. 2.

with the products of the explosion of the first shot: thus the second shot was fired into an atmosphere capable of being detonated, and it was detonated. Consequently, the permitted explosive caused an explosion in a mine, under conditions which, if reproduced experimentally on the surface under like conditions, would probably cause neither ignition nor detonation. There was no suggestion and no evidence that either of the shots was blown out or overcharged, or that they did not do as much work as they were required to do; and, consequently, if a naked flame fired the assumed mixture of over 2 per cent. of fire-damp and air, whence did it arise? On the other hand, assuming the conditions that were described in Mr. Atkinson's report, that there was no actual flame and in no sense a blown-out shot, but a detonating effect, the origin of the explosion was accounted for, and they were brought close up to an extremely awkward fact, namely, that explosives might be improved until ignitions of the surrounding atmosphere could not be produced experimentally, and yet one factor, which their present knowledge of explosives did not enable them to control, might carry a dangerous detonating vibration or percussive effect into distant parts of a colliery, and thus initiate other explosions of mixtures of fire-damp and air. In his (Mr. Ashworth's) opinion, blasting with the highest class of permitted explosives could not be made safe in a dusty, fiery mine until they were able to control detonating and percussive effects.

The position in which the body of Barnes was found showed that he was instantaneously rendered unconscious by air-percussion and then poisoned by carbon monoxide. Detonation and percussive effects were always most destructive at the face of narrow headings; and, therefore, Greenwell and Suggett were not affected in the same way as Barnes, and they were able to run some distance outbye before the after-damp killed them. The effect of the explosion on Barnes did not support the conclusion expressed by Mr. Atkinson:* nor did the Universal explosion support it; as the only man who escaped alive was in the roadway between the east and west sides of the pit, and must have been exposed to the passage of flame and force if they

* *Report to His Majesty's Secretary of State for the Home Department on the Circumstances attending an Explosion of Fire-damp and Coal-dust which occurred at Urpeth Colliery, near Birtley, in the County of Durham, on the 17th December, 1906*, by Mr. J. B. Atkinson, M.Sc., 1907 [Cd. 3494], page 14, lines 31 to 36.

had travelled, either from the east to the west, or from the west to the east, in the manner in which such effects were generally supposed to travel. He (Mr. Ashworth) did not look on the Urpeth explosion as one which ought to be designated a coal-dust explosion, as it was primarily due to fire-damp, and the flame was principally found in the return-airway, showing that it followed the mixture of gas and air until the percentage became so small by reason of air leaking through the stoppings and doors between the intake-airways and return-airways that it was too weak to burn. The great force, which tore out the steel girders, was doubtless due to the ignition of gas lodged above them in the broken faulted ground; and the coking of the dust was consequently due to the heat of the explosion of gas and not primarily to an explosion of dust. Another point concerning the coking of dust at Urpeth colliery deserved attention, namely, that the roads where it was found were naturally wet, and the air was saturated with moisture. A similar result was found at Udston colliery, the coking being heaviest in the wettest places; and similar results were found at Wingate Grange colliery. These facts could not, therefore, afford much satisfaction to those who pinned their faith to watering as a preventive of great disasters in collieries.

In conclusion, a pertinent query arose out of the *Report*, namely, if a mixture of 2 per cent. of fire-damp and air was a dangerous atmosphere in which to fire a shot of any permitted explosive, why were not safety-lamps, capable of detecting 1 per cent. of fire-damp, adopted for the use of deputies and shot-firers? There were no complicated parts in such lamps; the cost was very slightly in excess of that paid for the bonneted lamps used at Urpeth colliery; and it seemed absurd to use a safe explosive in a colliery, but to fire it in an unsafe atmosphere. Further, if an explosive was used in a gaseous atmosphere, as at Urpeth colliery, without the shot-firer being aware whether or not the atmosphere was safe or dangerous, it was clear that the General and Special Rules of the Coal-mines Regulation Acts were not enforced.

Mr. Donald M. D. Stuart (Bristol) wrote that the *Report* was of considerable importance, as it recorded an explosion of coal-dust at the coal-face, an almost unknown event in this

country. A fundamental element in dangerous coal-dust was admittedly its fineness of division, such as obtained in main haulage-roads; but this condition was supposed to have no existence at the coal-faces or in the immediate neighbourhood, as the coal-dust there had been regarded as incapable of ignition by fired gas or shot-firing. This explosion therefore required careful discussion. If coal-dust at the coal-face could be ignited to develop explosion, the danger of propagated explosions was more serious than had been supposed, and the present consensus of opinion that watering the coal-face was unnecessary required re-consideration. The question might be conveniently discussed by recalling the conditions in the workings where the explosion originated. The presence of coal-dust at the face and in its neighbourhood, sufficiently fine to be ignited and propagate an explosion, was demonstrated in the extensive deposition of coked dust. The presence of gas was equally certain, as it was yielded regularly and accumulated on the derangement of the ventilation. The existence of both coal-dust and gas appeared to complicate the case, suggesting a dual influence; but it would be a great advantage to the discussion if the function of these agents in the explosion could be discriminated, and for this purpose it was well worth enquiring into the facts. The *Report* supplied direct evidence on the question of gas: the seam yielded gas in constant flow from the advance-faces, which was diluted and carried away by the air-current by means of close bratticing. There had been no sudden outburst of gas in the workings; there were no goaves: consequently, there could be no gaseous accumulation. The working-faces comprised three headways and a stenton, and the complement of labour appeared to be four hewers, and two putters with ponies. To ventilate these workings and the cross-cuts leading to them, no less than 12,555 cubic feet of air per minute were passed through a regulator: a very generous supply even for advance-faces in a gaseous seam. The result of this ventilation was clearly recorded on the day of the explosion and immediately antecedent thereto. The *Report* showed that, within 13½ hours of the explosion, the stenton and the headways had been examined three times by different officials, namely, Sunday at 9 p.m., and Monday at 3 a.m. and 5 a.m. (the explosion occurred at 10.35 a.m.); the officials found the places free of gas, and two recorded the fact in writing in the report-books.

These reports narrow the time down to within 5½ hours of the disaster; at that time (5 a.m.), the deputy observed that the brattice-cloth at the face was too narrow to reach the floor, and that some air could short-circuit; he then laid more brattice along the floor, and compelled the full current of air to sweep the face, thereby effecting a more thorough dilution and removal of gas than obtained when he made his examination. About one hour later, the deputy left the district in a fit condition for shot-firing, and gave charge at 9·50 a.m. to the incoming deputy, telling him to go direct to the district, as shots would be ready for firing. This deputy would reach the district about 10 a.m., make the examination for gas before shot-firing; and presumably he found no gas, as he fired the first shot. This shot did not bring all its burden, but left about a foot of socket on the hole; consequently the unexpended heat-energy of the charge was thrown into the stenton, and if gas had been present then it would probably have been ignited. There was no ignition, and it was obvious that there was no gas in the stenton within a very short time before the explosion. After firing the first shot, the deputy or hewer, or both, returned to the face of the stenton, took the cable from the discharged shot, coupled it to the wires of the second shot, retired to the central headways and fired it; and the explosion then occurred. The interval between the shots could not have exceeded 10 minutes; but it was suggested that gas might have been liberated from the coal-face by the first shot and accumulated there during this period. There was no evidence that the brattice-cloth was deranged by the first shot, or that the air-current was interfered with; and it was reasonable to assume that any fresh or abnormal efflux of gas at this time was carried away by the ventilation. During this interval of 10 minutes, and about midway, one or both of the men were at the face of the stenton with a safety-lamp raised to cast light upon the wires of the second shot near the roof to make the cable-connection, and if gas had been present it must have shown in the lamp without any special examination; and, in that case, the deputy would not have fired the second shot. The quantity of gas issuing from the coal-face of the stenton after both shots had been fired appeared to have been limited, as 10 hours after the explosion, with the main return-airway blocked by a heavy fall, and canvas-doors and brattice-cloths deranged, the accumulation was

inadequate to prevent momentary examination of the face with an electric lamp, although it was unadvisable to do so with an ordinary safety-lamp. The positions of the headways, however, showed that the gas in this advance-working had been already tapped. The left and central headways had probed the seam in advance of the stenton, and the right headways had advanced across its face; the gas in the coal in the immediate vicinity and in advance of the stenton had therefore been drawn off to a material extent. In these circumstances, it was scarcely possible to conceive that there was any appreciable gas in the stenton when the explosion occurred. It was suggested that there might have been 1 or 2 per cent. of gas in the air-current and that the dust raised and left in suspension by the first shot had determined its ignition. There was no doubt that such a mixture of air, gas and dust had been inflamed by experiment, but it would scarcely be suggested that 1 or 2 per cent. of methane with 98 to 99 per cent. of air possessed any thermal value to produce the phenomena of this explosion. There were other evidences by which the suggested ignition of dilute gas might be examined. It was recorded that the brattice-cloth in the stenton was only partially displaced; the common experience in ignitions of very small quantities of gas in bratticed roads was that the brattice was wholly displaced, especially when the return air passed on the inside as in this case; and a "smart explosion" or even a gaseous ignition would surely have thrown down all the brattice in the stenton. The air travelled from the face of the left headways, round the face of the central headways, thence to the face of the stenton and onwards through the face of the right headways, receiving the gas *en route*; probably the air-current contained the least gas at the left headways, but receiving successive increments at the central headways and stenton became most highly charged at the coal-face of the right headways. The records showed that the flame did not reach the coal-faces of the left, central or right headways; the hewer in the left one was not burnt, the brattice-cloth in the right one was not displaced; if the supposed gaseous ignition did occur in the stenton, it would in natural course follow the train of gas to the coal-faces of the central and left headways on one side, and the coal-face of the right headways on the other, in the same way as a train of gunpowder when lighted midway burns to both ends; and, in the absence of these extended effects, it was difficult to conceive that gas had been

ignited in the stenton. In view of the facts that the stenton was examined by three officials during the 13½ hours preceding the explosion and within ½ hour of the disaster; that the first shot was fired there within 10 minutes of the event; and that there was no gaseous ignition in the faces of the headways on either side of the stenton, although they were part of the same atmosphere, the conclusion appeared to be reasonably established that fire-damp was not an element in the origin of the explosion, and that coal-dust was the only explosive agent ignited by the second shot.

This conclusion involved the proposition that coal-dust *per se* at the coal-face and its vicinity could be ignited and cause a propagated explosion. The past experience of mining engineers in this country was opposed to this postulate. The records showed that the principal explosions originated in main or secondary haulage-roads, where the coal-dust was in a fine state of division. There appeared to be one exception only: the Apedale colliery explosion, in the year 1891, originated by a shot igniting coal-dust at the coal-face, corresponded with the explosion at Urpeth colliery in that important point. These two exceptions, to the practically overwhelming mass of mining experience, required careful consideration. The conditions at the coal-faces must be elucidated, to ascertain whether they compared with the condition of main haulage-roads; if the comparison existed, enquiry was necessary into the causes, as if the dangerous dust zone of the haulage-roads extended into the coal-faces they possessed a potential danger that either a gaseous ignition or a shot could develop into terrible activity. The behaviour of coal-dust in a coarse or granular condition, and in a fine state of division, when subjected to heat for the extremely short time that obtained in gaseous ignitions and shot-firing, was so distinct as to form a clear line of demarcation, on one side of which the granular dust was comparatively innocuous, and on the other the impalpable dust was inflammable, instantly yielding explosive gases and developing explosion. This was not simply an experiment of laboratory-practice, but the admitted practical solution of the fact, notwithstanding the numerous gaseous ignitions and enormous amount of shot-firing at the coal-face, that there had been no ignition of coal-dust there (excepting the explosions at Apedale and Urpeth collieries); while the very

limited shot-firing in the haulage-roads had frequently ignited fine coal-dust from atmospheric suspension, causing disastrous explosions. Applying these data to the explosions at the Apedale and Urpeth collieries, it would be expected that the coal-dust in the coal-faces was in fine division. In both collieries, the coal was blasted, and the effect of different blasting agents was well-known. The non-detonating explosive was generally described as "spreading" and rending the face of coal; the detonating as "local" and shattering the coal. If the hole in which an explosive was fired could be examined, the class of explosive used, whether detonating or non-detonating, could be determined: if non-detonating, the walls of the hole would be split open; if detonating, the walls round the charge would be pulverized, and a chamber of impalpable coal-dust produced. This impalpable dust was naturally deposited at the coal-face and in the neighbourhood. The powerful and instantaneous shock of detonation was concentrated locally in the coal-face, and necessarily the coal that had received this shattering impact gave off fine dust during the extraction and filling into the tubs. The records showed that a non-detonating explosive had been excluded from Apedale colliery some time before the explosion, and a detonating explosive substituted at the coal-face. The inevitable effect was the production of impalpable coal-dust in the face and neighbourhood, and finally its ignition by a shot, with a disastrous explosion. The *Report* under discussion showed that a detonating explosive was used in the coal-face at Urpeth colliery; and the explosion, with the accumulated residues of coked coal-dust, demonstrated that this explosive had produced coal-dust so impalpable that it was ignited by the almost instantaneous exposure to heat from the shot, and caused propagated explosion. The awful explosion at the Courrières collieries in 1906 was another illustration, as there also the explosion probably originated at the coal-face, where a detonating explosive was used; and it was believed that the disaster was due to the ignition of the coal-dust by a shot. There might possibly have been some other factor than the fine state of division of the coal-dust at Apedale, Courrières and Urpeth collieries, and feasible suggestions might be offered; but, as they could neither be affirmed nor denied, they would not assist this discussion, and the substantial fact remained that the coal-dust at the coal-faces of

these collieries was in the dangerous condition that obtained in main haulage-roads, and that condition was brought about by the use of detonating or shattering explosives.

It would be most useful to know how far this dangerous coal-dust prevailed at coal-faces. With the fact that over 11,000 tons of explosives were annually consumed in mines and quarries, chiefly in coal-mines, the greater proportion at coal-faces, and that only two explosions by ignition of coal-dust at coal-faces had been recorded, the danger seemed to be somewhat remote: it should, however, be remembered that, until comparatively recent years, a non-detonating explosive was exclusively used in coal, and non-detonating explosives were still used to the extent of over 68 per cent. of the total consumption. Further, the permitted non-detonating explosive, which might be assumed as used only in coal, was more largely consumed than any other on the permitted list; in fact, last year, the consumption was more than 18 per cent. of the total quantity of the 42 permitted explosives used. The freedom from explosions by ignition of coal-dust at the coal-face had been obtained with non-detonating explosives. The record of safety here had been broken by detonating explosives: and the explosions at Apedale, Courrières and Urpeth collieries were object-lessons of a new danger with coal-dust, created by these explosives. The nature of that danger was seen in the fact that the paths or deposits of coal-dust extended from the coal-face to the shaft, and, if explosions were initiated in coal-dust at the coal-face, propagation to the shafts was the terrible probability. He (Mr. Stuart) hoped that the gravity of the subject would be accepted as cause for discussion at such length, and he would add his appreciation of the many important observations recorded in the *Report*, which he thought was a valuable contribution to the subject of colliery explosions.

Mr. W. C. Blackett (Durham) wrote that, as he had had an opportunity of investigating the cause of the explosion at Urpeth colliery, he could not allow some of the speculative views thereon, which had been advanced, to pass without comment.

To anyone, who had ever had the interesting experience of an ignition of fire-damp passing over him, there should appear little difficulty in forming a conception of all that happened at Urpeth colliery, and there was little need to strain the imagination as to what took place to cause the ignition. Explosion was an

unfortunate word, which to many minds caused an impression of greater and more sudden violence than was often found to be the case. To go a step further and begin to think of detonation was worse still, and was, besides being unnecessary, quite unwarranted. Mr. Ashworth had expounded many useful views on matters akin to this in the safety of mines, but surely he could not expect many people to conceive the possibility of simultaneous detonations at long distances apart, all set up by percussive action in the elastic medium of the air in the galleries of a mine. There was not the slightest evidence of any such phenomena at Urpeth colliery. It might be here stated that a very careful examination was made of Barnes, and that Mr. Ashworth was quite mistaken in saying that the position of the body indicated instantaneous unconsciouness by percussion. The body actually indicated a typical death from carbon monoxide and that only.

It was somewhat curious to find two such well-known observers as Messrs. Ashworth and Stuart, both, from one and the same report, deriving authority to conclude in the one case that gas was the chief delinquent, and in the other that it was dust. So easy was it for one man to miss completely the meaning of another's expression that Mr. Ashworth actually took a perfectly sound remark by Mr. J. B. Atkinson to mean that "'dry' coal-dust was a controlling factor in bringing an explosion to a termination." Mr. Atkinson would doubtless correct this misapprehension, but it was not easy to believe that there was any second person who could draw out such a conclusion as this.

Digressing for a moment, it was not easy to see how Mr. A. L. Steavenson got his idea that there was no evidence of gas, nor on what grounds he so decidedly blamed the stemming. How could the stemming be so very seriously to blame when it had not been blown out, and much of it was left intact in the fore-end of both shot-holes?

The following, however, were the chief points of evidence on which to build a reasonable common-sense theory of what really happened at Urpeth:—(1) The working-places were giving off a regular supply of fire-damp, which, after the explosion, in a sluggish air-current (sufficient, however, to re-ventilate the galleries), showed a cap on the ordinary safety-lamp. (2) The ventilation in Suggett's stenton, being controlled by brattice-cloth,

would tend also to be sluggish, even before the explosion, and it was also a heavily-rising place, in which such air as could flow would find its way in and around the brattice-cloth next the floor, without complete diffusion with the lighter and warmer gases above. (3) There was, as was common in the Busty seam, a good deal of coal-dust, which, although perhaps not so fine and impalpable as that on a haulage-road, was yet quite capable of being momentarily raised in the air by such a sudden shock as that from a shot. (4) Two shots had been fired, one before the other. Both shots had so acted as to shoot down only the back-end of the coal, leaving portions of the fore-end undisturbed with the stemming (of coal) still in the holes. (5) A careful examination suggested that neither shot had enough work to do, and that the second had probably had much less to do than the first shot.

Neither the deputy nor the hewer were very careful men, otherwise the shot-holes would not have been stemmed with small coal when clay was lying within a very few feet, nor would the shot-box have contained more than the statutory quantity of explosive. Whether from such men a very careful examination for gas was to be expected was very doubtful; but, at any rate, the first shot was fired without inflaming any gas. It was still more doubtful that any examination was ever made for the second shot; but, in any case, a merely perfunctory examination could easily have failed to notice what ought to have been seen.

The first shot would certainly raise some dust, and it was well known what a mixture of dust with an otherwise harmless amount of fire-damp could do. But also it must be remembered that the first shot would not only stir up the dust, but would develop, in a close place, a good deal of heat, and Dr. P. P. Bedson had shown what a small amount of heat could effect in the way of occluding gases from comparatively large surfaces of exposed coal. There might, therefore, in addition to dust, be even more gas for the second shot to fire into than was the case with the first, and there was also very probably more heat than work from the explosion. A more or less gentle ignition then took place, which at first probably wavered and flickered about in the upper part of the gallery, heating and expanding the atmosphere and also distilling out more gas from the raised dust. Such a heating

and expansion of air could not take place in a cul-de-sac without causing an outward current and pressure. The increased current stirred up more dust, and the increasing pressure of slightly gas-laden air produced more favourable conditions for combustion. At last, the volume of expansion became greater, and developed sufficient pressure to knock out critical props and allow falls to take place, which subsequently lent a false appearance of great violence. And finally, the outrushing volume passed the water, and ignition ceased for want of dust and prepared conditions.

In the meantime, so much dust had been raised and so small was the oxygen-supply, that very incomplete combustion took place, and a thick dense pall of black smoke filled the atmosphere, parts of which even then had begun to cool. As it cooled, the contents of the galleries contracted and a slow returning current was set up, depositing oily dust upon the outbye side of props and other objects. Also it began to "rain" a black oily soot, which covered all horizontal surfaces with a thick blanket, serving to indicate how plentiful had been the fuel and how inadequate the combustion.

The men were all killed by the deadly carbon monoxide; but so fleeting had been the contact of heat that their hair and woollen clothing barely indicated a crisp scorching, and not even this in the case of Barnes.

What need was there of any less simple theory than this? Presumably no one would pause to doubt that they were dealing only with a mixture of air and gas: there would be greatly varying conditions of ignition or explosion, depending entirely on the relative admixture of the gases and also on whether diffusion was more or less complete. Thus, where pure undiffused gas came into contact with air, only the point of mixture would burn; and it could only be simultaneous where complete diffusion had taken place more or less uniformly throughout, and then the violence would depend on the relative mixture. It was quite conceivable that a correct molecular mixture of gas and air could fill a mine, and be simultaneously exploded or even detonated on the application of flame; but such a condition was inconceivable with dust. An ignition of dust and air must always be a travelling phenomenon, varying in intensity at its flame-point with the more or less favourable condition prepared by the pioneering air-rush. Here, the dust raised and the pressure

would be scant and small, giving feeble but still fire-bearing results. There, the mixture of dust and heated air-pressure would be more chemically correct, and violence great enough to justify the use of the term explosion would result. It was conceivable, too, that a coal-dust ignition could be so prolonged that at one end of its path expansion and progression could be taking place; while, at the other, the exact contrary might obtain, as also a "back-lash," which might even be fed by an out-flow from the return-airways and produce some of those contradictory evidences of force-direction which had so often puzzled observers.

No mechanical mixture of dust and air could ever act like the diffused molecular conditions of gases.

To talk therefore of detonating a mixture of dust and air would be almost as vain as to speak of detonating a train of gunpowder.

Dr. P. Phillips Bedson (Armstrong College, Newcastle-upon-Tyne) wrote that, with respect to the analyses of the samples of coal-dusts submitted to him by Mr. J. B. Atkinson, it might be pointed out that the ratio of fixed carbon to volatile matter afforded information as to the extent of coking. For a given coal, this ratio varied within certain limits and was more or less characteristic of the coal in question. When the coal was strongly heated or partly burnt, the ratio would alter by reason of the diminution of the volatile matter, so that the ratio gave an indication of the extent to which the coal of a given sample had been heated. Taking the analyses of coals from the Busty seam,* this ratio of fixed carbon to volatile matter varied from 2·39 to 2·77, and the average of five samples was 2·56. Analyses made in the Armstrong College laboratories gave for the bright coal from the Busty seam 2·03; and for the dust from the screens of Birtley colliery, kindly supplied to the writer by Mr. Philip Kirkup, this ratio was 2·17, whilst for dant, from the same seam, the ratio was 4·96. It might be taken, therefore, that the ratio in question for coal from the Busty seam would vary between the limits of 2·03 and 2·56. Bearing this in mind, it would be noted that the analyses of the samples collected by Mr. Atkinson showed that the dust had been more or less

* *Analyses of British Coals and Coke, and the Characteristics of the Chief Coal-seams worked in the British Isles*, 1907, page 25.

coked. The extent of the coking was exhibited in a more marked degree by samples of materials from the Urpeth explosion sent to the writer by Mr. Philip Kirkup. In one case, the ratio was 4, and this represented a sample of dust collected from the inbye-side of timber between the two stentons nearest the coal-face where the explosion started, whilst in another sample, collected from the outbye-side of the props, the ratio was 3·28. Mr. Kirkup had sent the writer a third sample, of sooty matter, found on the flat sides of timber, with a ratio of 2·63. The observations of Mr. F. G. Trobridge,* a student of Armstrong College, on the enclosed gases of the coal-dust produced from coal of the Busty seam, indicated that the dust was similar in this regard to that obtained from the Hutton seam at Ryhope colliery. Mr. Trobridge recorded the results of analyses of the enclosed gases obtained from bright coal, dant, surface-dust and also from dust lying on timbers, obtained from the Busty seam and kindly supplied by Mr. Philip Kirkup, which represented the products of the seam at Birtley colliery. These results showed that 100 grammes of each of these materials, when heated in a vacuum at 100° Cent., gave the following volumes of gas, measured at normal temperature and pressure: —

	Cubic centimetres.
Bright coal	139·0
Dant	35·0
Surface-dust	9·2
Dust from timbers	11·4

The analyses showed that these volumes represented 130, 21, 2·07 and 0·2 cubic centimetres, respectively, of combustible gas, which in the case of the bright coal and dant appeared to be entirely marsh gas; whereas the combustible constituents of the dust from the surface contained higher and denser members of the paraffin series, and were, in fact, similar in composition to the gases that the late Mr. W. McConnell and he (Dr. Bedson) had obtained from other dusts of the Durham coal-field.† Mr. Henry

* "The Gases enclosed in Coal and certain Coal-dusts," by Mr. F. G. Trobridge, *The Journal of the Society of Chemical Industry*, 1906, vol. xxv., page 1129.

† "A Contribution to our Knowledge of Coal-dust," by Prof. P. Phillips Bedson, *Trans. N. E. Inst.*, 1888, vol. xxxvii., page 245; part ii., by Prof. P. Phillips Bedson, *Trans. Inst. M. E.*, 1894, vol. vii., page 27; and part iii., by Prof. P. Phillips Bedson and Mr. W. McConnell, jun., *Ibid.*, 1894, vol. vii., page 32. "Notes on the Gases enclosed in Coal and Coal-dust," by Prof. P. Phillips Bedson and Mr. W. McConnell, *Ibid.*, 1892, vol. iii., page 307.

Widdas had found, in his experiments upon the inflammability of mixtures of coal-dust and air, that the bright coal from the Busty seam yielded a dust as inflammable as Hutton seam coal-dust, and, further, that the dust collected at the Urpeth screens belonged to the easily inflammable dusts. There could be no doubt, from Mr. Atkinson's *Report*, that the easy inflammability of the dust at Urpeth colliery played an important part in this explosion; and, further, it should be remembered that dust, freshly produced at the face, was more sensitive to inflammation than dust which had been exposed to the air for a considerable time.

Prof. H. Louis' paper on "A Locking Hook for Sinking Purposes" was read as follows:—

A LOCKING HOOK FOR SINKING PURPOSES.

By HENRY LOUIS.

In shaft-sinking, it is very usual to work with two kibbles, which are alternately attached to the winding-rope, so that one may be filled at the shaft-bottom, whilst the other is being emptied at bank. The kibbles are attached to the rope by means of an ordinary spring hook, and it may occasionally happen that a kibble drops off the hook, through the kibble being badly loaded, the spring being weak, or the kibble badly put on, etc. An accident of this kind caused the writer to devise the hook which forms the subject of the present note.

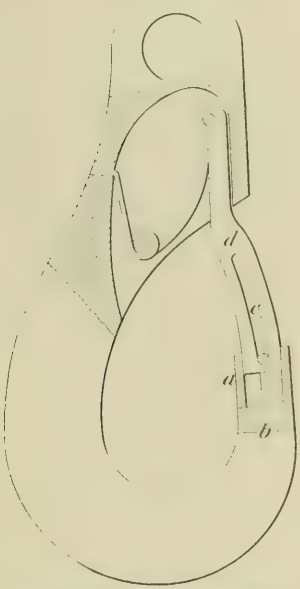


Fig. 1.—Safety Hook.
Scale, 4 Inches to 1 Inch.

A sliding ferrule, *a*, fitted to the tongue of the hook, is prevented from dropping off it by a pin passing through a slot, *c*, in the tongue, *d*. To open the hook, the ferrule is simply pushed upward as far as it will go, and when the hook is closed, the ferrule slides down over the point, *b*, of the hook, thus firmly locking the hook, which cannot be opened without sliding up the ferrule. The safety of the hook is thus independent of the spring, which may, indeed, be dispensed with if desired, although the writer prefers to retain it. Several of these locking hooks have been made and used, and are found to answer perfectly the object for which they were designed.

Mr. H. W. Hughes (Dudley, Worcestershire) wrote that the movement referred to by Prof. Louis was undoubtedly superior

to the ordinary spring, but it was by no means novel, as the sliding ferrule had been used for several years at the Baggeridge sinking, in South Staffordshire. Continual trouble being experienced by the breakage of the ordinary spring, or by its losing temper and becoming weak, the breakage was overcome by arranging the spring as shown in fig. 2. The small projection, A, prevented the spring from being dashed against the back of the hook, but it did not remove the disadvantage caused by the loss of elasticity in the steel. In order to prevent any possibility of the

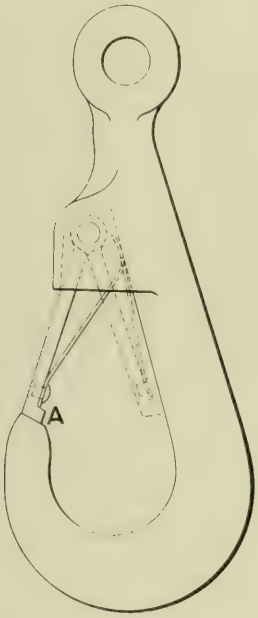


Fig. 2.—Spring Hook.
Scale, 6 Inches to 1 Inch.

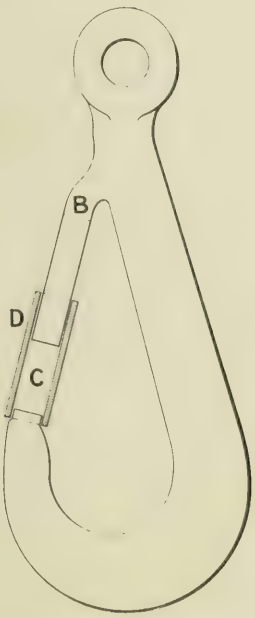


Fig. 3.—Safety Hook.
Scale, 6 Inches to 1 Inch.

bow of the kibble dropping off the hook, Mr. Ivor Morgan, enginewright at Baggeridge colliery, arranged for the hinge, B, of the spring-portion to be welded to the top, as shown in fig. 3, leaving a sufficient space, C, between the point of the hook and the slide-piece, D, for the bow to pass through: this was sealed during all ordinary operations by the sliding ferrule, D, which always dropped unless it was deliberately propped up. Experience had proved that the hook was more safe, when the spring was entirely dispensed with.

Prof. Louis wrote that he was interested in Mr. Hughes' remarks; and the fact that both Mr. Hughes and himself had been led to adopt the sliding ferrule for preventing the class of accident referred to, seemed to show that the idea was quite sound, although they had not both hit upon identically the same way of carrying out the idea. It seemed to him that Mr. Hughes' method might be better for very large hooks, and his own for smaller ones. He would like to add that, although the general design of the hook that he had described was his own, it was only right to point out that the details had been worked out by Messrs. Joseph Cook, Sons & Company, Limited.

Mr. J. G. Weeks moved a vote of thanks to Prof. Louis for his description of a safety-appliance.

Mr. A. L. Steavenson seconded the resolution, which was approved.

Mr. R. Cremer described the "Wolf-Bohres Electric Safety-lamp," as follows:—

WOLF-BOHRES ELECTRIC SAFETY-LAMP.

By R. CREMER.

The Wolf-Bohres electric safety-lamp, fitted with an osram lamp made especially for the purpose, is supplied according to two designs: one arranged to throw the light downward and the other upward. The osram glow lamp will give an equal light, while using slightly more than half the electrical energy required by a carbon lamp. The lamp is fitted with a single-cell accumulator, affording the advantage of a considerable reduction of the weight of the lamp and a more simple treatment of the accumulator. The average length of burning of a 2 volts osram lamp is 600 to 800 hours, against scarcely 100 hours for a 4 volts carbon lamp.

The lamp is fixed in a strong air-tight glass globe, mounted on the top of, or below, the accumulator, and accessible from all sides. The pure air enclosed between the glass globe and the glow lamp becomes heated by the burning lamp, and its pressure is thereby increased. Should the glass globe be smashed and the glow lamp injured, then the expanded heated air drives back the outer air of the mine, and will at the same time rush into the vacuum of the lamp, causing the filament of the lamp to be instantaneously destroyed. The circuit is thereby interrupted, and the glow lamp extinguished, before an explosive atmosphere has time to enter and to reach the light. Numerous tests made in explosible mixtures have shown that this lamp is safe, under all known conditions prevailing in mines.

The lamp is closed by means of a magnetic lock, which prevents unlawful opening and thereby producing sparks at the contacts. The top and bottom parts of the lamp are connected by slots and projections; and electric contact is formed by sliding two broad spring plates over the contact bridges of the accumulator. The contacts consist of a metal alloy, on which diluted sulphuric acid has a small and slow effect. The opening of the lamp is effected by withdrawing the iron-locking bolt by means of a magnet.

The single-cell accumulator, enclosed in a celluloid case, fits loosely into the lamp-body, and can be readily removed and replaced. The leads to the contact-pieces are bedded-in and are acid proof. The filling opening is fitted with a three-chambered screw-closing device, allowing any gas developed to escape, but preventing any acid from flowing out when the lamp is held in a slanting position.

The rectangular lamp-body, made of tinned sheet-steel, with round metal ends, is covered with an acid-proof paint.

The accumulator feeds the glow lamp, giving $1\frac{1}{2}$ to 2 candle-power, for 12 hours. The accumulator is connected up to a simple charging-device by plugs.

The weight of the lamp, ready for use, is 4 pounds, and the height is $10\frac{1}{2}$ inches.

Mr. J. G. Weeks, in proposing a vote of thanks to Mr. Cremer for his paper, stated that the Wolf-Bohres lamp was a step in the right direction, if it would burn 12 hours, although the weight was somewhat excessive. It was unfortunate that an electric lamp would not detect the presence of gas.

Mr. M. Walton Brown seconded the resolution which was cordially approved.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

EXCURSION MEETING,
HELD AT DUNSTON-UPON-TYNE, AUGUST 29TH, 1907.

FERRO-CONCRETE WORK AT DUNSTON-UPON-TYNE.

In addition to a warehouse built on the Mouchel-Hennebique system of ferro-concrete near the northern bank of the river

FIG. 1.—FERRO-CONCRETE GRANARY.

Tyne, at Newcastle, the Co-operative Wholesale Society, Limited, has adopted the same method of construction for the execution

of other interesting examples of architectural and engineering work in the district.

The most important of these buildings is erected at Dunston, and measures 155 feet in length, 110 feet in width, and 94 feet in height to the uttermost level. This structure (fig. 1) comprises a granary divided into fifty-six bins or silos for the storage of grain, and a grain-cleaning house surmounted by a tower containing a tank for water-sprinkling apparatus, while the main roof of the cleaning-house forms a water-storage tank, 4 feet deep. The building stands upon a continuous foundation-slab of ferro-concrete, connecting the heads of numerous piles

FIG. 2.—DISCHARGE-OUTLETS OF HOPPERS.

driven deep into the mud, which extends downward for the depth of about 80 feet. Each of the piles carries part of the load, the remaining part of the total load being transmitted to the surface of the ground by the general foundation-slab. This system of foundation work has been employed with great success in dealing with unstable soils, and it has proved very satisfactory at Dunston under the enormous weight of the building and its contents.

Each of the silos in the granary department measures 43 feet in height by 14 feet square, and has a storage-capacity of more than 600 quarters of grain, the entire series providing a total capacity of 35,000 quarters. Each silo is carried on ferro-concrete beams and columns beneath the partition-walls (fig. 2), an arrangement

which results in much economy of space and affords ample space for the conveyor-bands by which the grain is transported from the discharge-outlets of the hoppers at the bottom of the silos.

In the cleaning department, the engine-house occupies a space extending to a height of two stories, its roof being formed of arched beams with a clear span of 36 feet, which carry the columns affording intermediate support for all the floors above. These beams also carry a travelling crane of 10 tons and a traveller-beam, which is hung from brackets at one side of the engine-house.

To provide for the accommodation of vessels bringing wheat to the granary, a ferro-concrete wharf, partly in the form of a

FIG. 3.—FERRO-CONCRETE JETTY.

jetty, had been constructed to a length of about 420 feet. This structure consists of Hennebique piles continued in the form of columns, securely braced in every direction and connected by a continuous decking-slab. This jetty has been extended for a further length of 330 feet, thereby affording further accommodation for loading and discharging vessels, and, at the same time, opening the way for the reclamation of the area between the river-bank and the jetty. The extension (fig. 3), completed a few months ago, comprises twenty-one bays, each founded on six Mouchel hollow-diaphragm piles, having an average length of 45 feet, and built monolithic, with a ferro-concrete superstructure consisting of columns, walings, bracing and a continuous decking.

A novel type of granary-building, 176 feet long, 92 feet wide and 86 feet high above quay-level, is being erected on a reclaimed site, behind the original jetty. The main part of this structure will consist of six cylindrical grain silos, each measuring 70 feet in height from the top to the bottom-outlets, and 46 feet in internal diameter, and providing a total storage-capacity of nearly 60,000 quarters of wheat. These silos are arranged in two rows of three, and at each end there will be a rectangular wing containing smaller silos and accommodation for grain-cleaning machinery. This building is founded upon a number of Mouchel hollow-diaphragm ferro-concrete piles driven into the mud, and connected by beams of the same material below floor level, while a second series

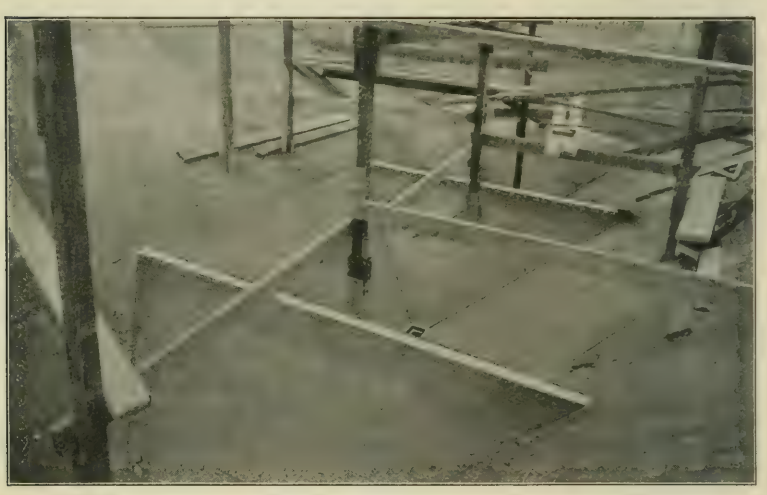


FIG. 4.—INTERIOR OF CIRCULAR GRANARY, IN COURSE OF ERECTION, SHOWING DISCHARGE-OUTLETS.

of beams in the floor-system will constitute additional bracing. The large silos are to be supported by columns and beams disposed so as to give the maximum amount of space for the conveyor-bands, and the other parts of the structure will be framed in accordance with the methods usually adopted in the Mouchel-Hennebique system of monolithic construction. A general floor will be carried above all the silos; and, as this is to be covered by a flat roof, an upper storey of considerable area will be placed at disposal. The structure is a novelty in the way of granary-design, and its bold lines are distinctly favourable to effective and striking architectural treatment.

Good progress had already been made in the foundation-work; and, judging from the extremely variable character of the subsoil, as evidenced by the experience of set obtained for piles quite near one to the other, it would be a very hazardous undertaking to attempt the erection of so large and heavy a building, on so treacherous a site, without the aid of ferro-concrete.

The erection of a soap-factory has been commenced on the existing bank of the river behind the jetty-extension; but, in course of time, the area of water and mud between these two structures will be reclaimed. This building will be a three-storey structure, 265 feet long and 120 feet wide. It is founded upon Mouchel ferro-concrete piles, and built throughout of ferro-concrete on the Hennebique system.

On completion, the establishment of the Co-operative Wholesale Society, Limited, at Dunston, will comprise an interesting series of structures representing the most recent types of ferro-concrete construction.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

EXCURSION MEETING,
Held at Felling, August 31st, 1907.

The members were present at the annual inspection of the Felling Colliery Corps (No. 6 District) of the St. John Ambulance Brigade, and at a demonstration of rescue-apparatus, for use in mines, in a model gallery. They afterwards inspected the electric pumping plant at Tyne Main colliery.

ELECTRIC PUMP AT TYNE MAIN COLLIERY.

The Hutton seam, in Gateshead Park royalty, leased by Messrs. John Bowes & Partners, Limited, is now practically exhausted and standing full of water; and probably the High Main seam was also worked, but there are no plans or records of the workings in this seam in existence. It is now proposed to work the seams lying between the High Main seam and the Hutton seam to the Felling shaft; but, before this can be accomplished, the water standing in the Old Fold and other shafts must be pumped out. As the diameter of the Old Fold pit is only 8 feet, it was decided that an electrically-driven pump was the only feasible means of draining the shafts. The total depth to the Hutton seam is 564 feet. The shaft was originally divided by a brattice, which is being taken out as the water is reduced.

A Mather-and-Platt high-lift turbine-pump has been put in, driven by electrical power. This pump consists of eight sets of vanes or impellers; each set runs in its own chamber, upon a common shaft, and the delivery-pressure of the water varies directly with the number of chambers used. Thus, if an ordinary single pump can deliver water against a head of 30 feet, the addition of another chamber will give a final delivery-head of 60 feet, and so on. The water enters axially into the

revolving wheel, traverses the curved internal passages between the vanes, and is discharged tangentially at the periphery into a stationary guide-ring of special construction. It is then conveyed to the annular chamber in the body of the pump, where the velocity-head imparted to the water by the wheel is converted into pressure-head. From this chamber, the water is finally discharged into the second and subsequent chambers, and then into the rising main. The stationary guide-ring is fixed concentric with the revolving vanes, and, owing to its design, enables the conversion of velocity-head into pressure-head to be carried out in a much more perfect manner than is possible in the case of any other centrifugal pump; and, consequently, the possible height of lift and the efficiency of the pump are greatly increased. The motor driving the pump has an output of 170 horsepower, when running off a circuit at a pressure of 440 volts and a frequency of 40 cycles per second, at a speed of about 1,200 revolutions per minute. The motor is of the short-circuited rotor-type, the rotor being carried on ball-bearings. The motor is completely enclosed, and the stator is air-jacketed. The motor is started, from the surface, by means of an automatic transformer-starter of the oil-cooled type. The switch controlling the transformer is also oil-immersed.

The pump is designed to raise 500 gallons per minute against a total head of 565 feet. At the present time, with a less head, about 800 gallons per minute are being delivered. The level of the water is now 216 feet below the surface, and when the pump commenced it was 122 feet.

The crab and jack-winch is also driven by an electric motor of 15 horsepower.

The current is supplied by The County of Durham Electrical Power Distribution Company, Limited.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
OCTOBER 12TH, 1907.

MR. J. H. MERIVALE, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on August 17th, September 28th and that day.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. WILLIAM Bell, Colliery Manager, Plashetts Coal and Coke Company, Plashetts, S.O., Northumberland.

Mr. WALTER JAMES BROWNING, General Manager, Mazapil Copper Company, Limited, Concepcion del Oro, Estado de Zacatecas, Mexico.

Mr. ROBERT WILLIAM CHURCH, Mining Engineer, Dragon Villa, Durham.

Mr. GEORGE ALEXANDER CURRY, Colliery Manager, Thornley House, Thornley, S.O., County Durham.

Mr. ROBERT WILLIAM GLASS, Colliery Manager, Axwell Park Colliery, Swalwell, S.O., County Durham.

Mr. HENRY MALKIN HANCE, Mining Engineer, Nagpur, Central Provinces, India.

Mr. HOWELL ARTHUR HOPWOOD, Mining Engineer, General Manager, Bandgermassin Coal and Diamond Fields, Dutch Borneo.

Mr. ISAAC JOHN HOPWOOD, General Manager, Sungei Tiram Tin-mines, Johore, care of Post Office, Singapore.

Mr. MATTHEW ROBSON KIRBY, Mining and Mechanical Engineer, Holywell Hall, Durham.

Mr. GEORGE AUGUSTUS LONGBOTHAM, Mechanical Engineer, Ings Foundry, Wakefield.

Mr. JOHN STRAKER NESBIT, Colliery Manager, Marley Hill Colliery, Swalwell, S.O., County Durham.

Mr. THOMAS ELLIOT PARRINGTON, Mining Engineer, Hill House, Monkwearmouth, Sunderland.

Mr. FRANK REED, Inspecting Engineer of Mines, Mines Department, Wellington, New Zealand.

Mr. Percy Edmund Smallwood, Colliery Manager, Garesfield Colliery, High Spen, Newcastle-upon-Tyne.

Mr. Francis Joseph Stephens, Superintendent, Blackwell's Development Corporation, Limited, Knaben Grube, Fjotland, *via* Flekkefjord, Norway.

Mr. Frank Reginald Watts, Nut and Bolt Works Manager, Cleveland House, North Shields.

Mr. Matthew Brown Wild, Colliery Engineer, 37, Arthur Road, Erdington, Birmingham.

Associate Members—

Mr. Noel Collingwood Dickson Borradaile, Motor Mine, Gatooma, Rhodesia, South Africa.

Mr. Edward Otto Forster Brown, Springfort, Stoke Bishop, Bristol.

Associates—

Mr. Daniel John Davies, Deputy, Corrimal, near Sydney, New South Wales, Australia.

Mr. Thomas Emmerson, Surveyor, Lucas Street, New Silksworth, Sunderland.

Mr. Robert Graham, Deputy Overman, 31, Railway Terrace, Willington, S.O., County Durham.

Mr. John Swanstone Jobling, Miner, 10, Langley Street, Langley Park, Durham.

Mr. Edward Middlemass Lewiss, Mechanical Draughtsman, 3, Eighth Row, Ashington, Morpeth.

Mr. George Austin Septimus Rogers, Mechanical and Electrical Engineer, Greenhead Terrace, Chopwell, Ebchester, S.O., County Durham.

Mr. Joseph Snaith, Colliery Under-manager, South Pontop Colliery, Annfield Plain, S.O., County Durham.

Students—

Mr. Samuel Bailey Coxon, Mining Student, Prior House, Corbridge, S.O., Northumberland.

Mr. Albert Ernest Fowler, Mining Student, Usworth Villa, Washington, Station, S.O., County Durham.

Mr. Henry Hepburn, Mining Student, Greenhead Terrace, Chopwell, Ebchester, S.O., County Durham.

Mr. Henry Moore Hudspeth, Apprentice Mining Engineer, Willington, S.O., County Durham.

The following paper by Messrs. P. Phillips Bedson and Henry Widdas on "Experiments illustrative of the Inflammability of Mixtures of Coal-dust and Air" was read as follows:—

EXPERIMENTS ILLUSTRATIVE OF THE INFLAMMABILITY OF MIXTURES OF COAL-DUST AND AIR: PART II.

By P. PHILLIPS BEDSON, D.Sc., and HENRY WIDDAS, B.Sc.

In a paper* recently read before this Institution, a form of apparatus was described by which the inflammability of mixtures of coal-dust and air could be studied, and on that occasion it was shown that whilst a small gas-flame would ignite a cloud of coal-dust, it failed to inflame a mixture either of charcoal-dust or of dant and air. Substituting for the gas-flame that of a Bunsen burner, or, better still, a Mecker burner, in both of which a flame of much higher temperature is produced than in a luminous gas jet, it is possible to procure an inflammation of charcoal and of dant. This shows that the temperature of ignition of such mixtures is much above that of an ordinary bituminous coal-dust. But, even with a luminous flame, a difference between coal-dusts from different coals is shown by the amount of dust required to produce an inflammation. Thus, it has been found that with brown coal 0·1 to 0·2 gramme (1½ to 3 grains) suffices to produce an ignition, whereas with Busty seam bright coal 0·2 gramme (3 grains) and with Barnsley cannel and Hutton seam coal, 0·8 gramme (12 grains) of each are needed to give a distinct inflammation.

With the object of comparing the relative inflammability of coal-dusts of different origins, the authors determined to replace the coal-gas flame in the apparatus, described in the former paper,† by a coil of platinum wire suspended in the box from the upper opening. Since by heating the wire, by passing through it an electric current, a considerable range of temperature could be secured; and further by employing the

* "Experiments illustrative of the Inflammability of Mixtures of Coal-dust and Air," by Messrs. P. Phillips Bedson and Henry Widdas, *Trans. Inst. M. E.*, 1906, vol. xxxii., page 529.

† *Ibid.*, vol. xxxii., page 530.

same wire and of a given length, and measuring the current used to cause the wire to glow, a measurement is got which gives an indication of the temperature attained in a particular experiment. Thus, the number of ampères used to ignite equal weights of coal-dust serves to indicate the relative inflammability of dusts of different sources. For example, with 1 gramme (15·4 grains) of dust in each instance, the currents recorded in Table I. were required with the apparatus used to produce inflammation.

Table I.—Current, in Ampères, to produce Ignition.

Dusts.	Ampères.
Brown coal	10·5
Busty seam, bright coal	11·5
Hutton seam, coal	11·5
Lycopodium	11·5
Brockwell seam, cannel	12·5
Harvey seam, splint	17·0

With dust from anthracite, and also from dant, no ignition was obtained with a current of 17 ampères; and it was not deemed desirable to use a greater current, for fear of fusing the wire.

The dusts employed in these experiments were made by grinding the coal and sifting through a No. 100 sieve, and were simply air-dried. The effect of drying the coal-dust after grinding was evidently to lower the temperature of ignition, as shown by the somewhat smaller current required in each case (Table II.).

Table II.—Current, in Ampères, to produce Ignition of Dried Dusts.

Dried Dusts.	Ampères.
Brown coal	9·8 to 10·0
Busty seam, bright coal	11·0 to 11·5
Hutton seam, coal	11·0 to 11·5
Brockwell seam, cannel	11·5 to 12·6
Harvey seam, splint	13·0 to 15·0

The influence of moisture was further tested by exposing the dust for a lengthened period to moist air: the dust for this purpose was placed on a shallow tray, under a bell-jar standing over a dish of water. Brown coal-dust, after 72 hours' exposure to moist air, and Hutton seam coal-dust after an exposure of 96 hours, required currents of 12·2 and 13·5 ampères, respectively, for their ignition: representing an increase of approximately 2 ampères above that required for the dried materials. In the case of the Hutton seam dust, this exposure would represent an increase in the proportion of moisture

from 1·5 to 2·12 per cent. In another set of experiments, freshly-ground dust was made into a paste with water, and was then allowed to dry by exposure to the air; on the sixth day it was dry enough to form a cloud in the apparatus, and was then found to contain 3·1 per cent. of moisture. This air-dried coal required 13·5 ampères for its inflammation, the freshly-ground coal requiring 12·5 ampères. The coal was again made into a paste with water, and the paste allowed to dry spontaneously in the air; on the fourth day it was so damp that it did not form a cloud, and then was found to contain 13·72 per cent. of moisture; on the fifth day it formed a cloud which ignited with 13·8 ampères: the dust then contained 3·77 per cent. of moisture. After 8 days' drying, the dust was found to contain 1·78 per cent. of moisture, and required 13·8 ampères for its ignition.

It is evident that, to prevent the ignition of an inflammable coal-dust, it must be so damp that it cannot be blown into a cloud by a jet of air, and further that an increase in the proportion of moisture has a tendency to raise the temperature of inflammation.

A dust becomes less sensitive to ignition by lengthened exposure to the air, as is shown by the fact that a freshly-ground dust, which at first ignited with 12·5 ampères, after 17 days' exposure to the air, required 14 ampères for its ignition.

The effect of mixing incombustible solid matter with coal-dust is not only to retard the inflammation, but also to raise the temperature to which the mixture must be heated in order to produce an ignition. In support of this, the following experiment may be cited:—One gramme (15·4 grains) of brown coal-dust was ignited with 12·5 ampères; a mixture of 1 gramme (15·4 grains) of this dust with 1 gramme (15·4 grains) of dry sand gave an inflammation four times out of six, with a current of 13 ampères; with a mixture of 1 gramme (15·4 grains) of coal to $1\frac{1}{2}$ grammes (23·1 grains) of sand and a current of 13·5 ampères, ignition occurred three times out of four; whereas by increasing the proportion of sand to twice that of the coal 15·5 ampères were required to attain inflammation.

Using coal from the Hutton seam in a similar manner, the following results were observed:—1 gramme (15·4 grains) of coal alone, required 12·5 ampères; 1 gramme (15·4 grains) of coal with 0·5 gramme (7·7 grains) of sand, required 13 ampères;

1 gramme (15·4 grains) of coal with 1 gramme (15·4 grains) of sand, required 14 ampères; 1 gramme (15·4 grains) of coal with 1·5 grammes (23·1 grains) of sand, with 14 ampères, gave a feeble inflammation; 1 gramme (15·4 grains) of coal with 3 grammes (46·3 grains) of sand, with 15 ampères, gave practically no inflammation.

A few experiments have been tried to show the influence of charcoal, when mixed with an inflammable coal-dust. A mixture of 1 gramme (15·4 grains) of charcoal and 1·5 grammes (23·1 grains) of Hutton seam coal-dust was found not to be ignited, even with a current of 16 ampères. On the other hand, charcoal, when moistened with petrol and then exposed to the air until apparently dry, carried enough petrol to make it easily inflammable. In fact, 1·5 grammes (23·1 grains) of charcoal, so treated, gave a decidedly explosive inflammation with 15 ampères. On standing exposed to the air for two days, the charcoal ceased to act in this way.

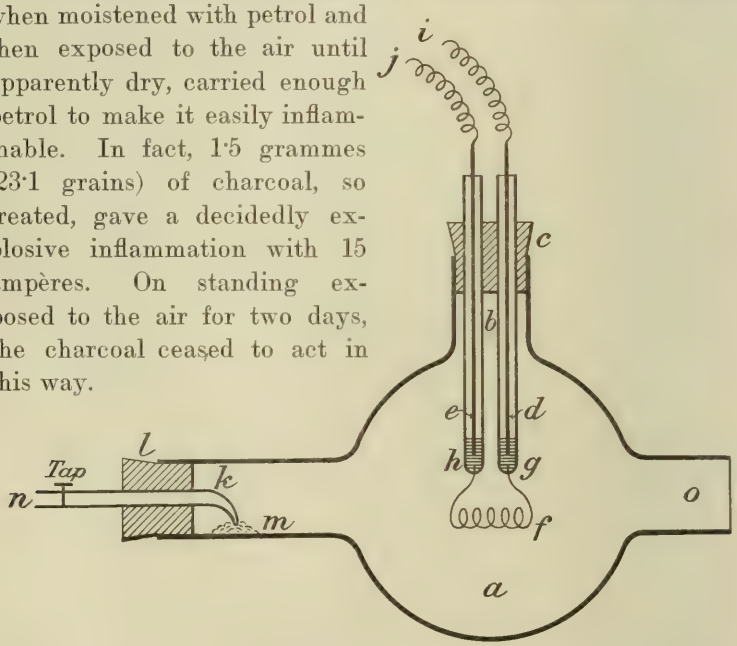


Fig. 1.—Explosions Vessel. Scale, 4 Inches to 1 Inch.

Whilst these experiments may be regarded as affording distinct evidence of the difference exhibited by coal-dusts in the formation of inflammable mixtures with air, they also show something as to the influence of moisture, and of the deadening effect of incombustible matter and of non-volatile combustible substances; still, they leave much to be desired in the way of precision as to the result of the inflammation. This can only be gauged by the eye and registered as violent inflammation, a

slight puff or no ignition, as the case may be. An attempt has been made to gain more exact information in the following manner:—An explosions vessel, *a*, has been constructed of glass, spherical in form, and of about 2 litres (122 cubic inches) capacity. The vessel is provided with three tubulures; one, *b*, for the insertion of an indiarubber stopper, *c*, through which pass two glass tubes, *d* and *e*, and into the closed ends of these are fused the ends of a coil, *f*, of platinum wire. The tubes contain a small quantity of mercury, *g* and *h*, into which dip iron wires, by which the platinum wire can be electrically connected with the terminals, *i* and *j*, of a battery and a current passed through the platinum to raise it to the desired temperature. A second tubulure, *k*, serves for the introduction of the coal-dust, *m*, and connection, *n*, with the air-compressor. Whilst to the third tubulure, *o*, is attached the apparatus which serves to register the pressure developed by the inflammation of the dust. The apparatus employed consists of a large three-necked Wolff bottle, one opening of which is connected by tightly-fitting stoppers and glass tubing with the explosions vessel; to the second is fitted a simple gauge, consisting of a U-shaped tube, the bend of which contains coloured water, the end of the tube being sealed. In the third opening of the Wolff bottle is fitted an indiarubber stopper carrying a glass tube, to the open end of which is attached a piece of indiarubber tubing closed by a spring clip. It is evident that, by this arrangement, the sudden pressure produced by the inflammation inside the explosions vessel would make itself evident in a compression, registered by the movement of the liquid in the U tube. The extent of this movement is registered by the aid of a scale attached to the closed limb of the U tube.

Using the same weight of coal-dust, and the same current, it was found that the same coal gave quite consistent results, that was, practically the same compression. Further, the same weights of different coal-dusts gave different compressions. Thus, on using the same weight of coal-dust, and the same number of ampères for heating the platinum wire, the compressions registered would represent, on an arbitrary scale, the explosive character of the mixture of dust and air.

A number of samples of coal-dust have been examined in this way, some of these dusts representing samples collected in mines, while in other cases the dusts represent coal ground in the

laboratory. In Table III., giving these results, the former are described as natural dusts, the latter as artificial. It will be seen that the compressions registered vary from a negligible amount to 5 inches. It should be mentioned that the weight of dust used in each case was 2 grammes (30·8 grains), the air used to project the dust was under a pressure of about 8 inches of mercury, and the wire was heated by a current of 15 ampères.

Table III.—Explosive Character of Dusts.

No. of Experiment.	Nature.	Moisture.	Volatile Matter.	Fixed Carbon.	Ash.	Ratio of Fixed Carbon to Volatile Matter.	Ratio of Fixed Carbon and Ash to Volatile Matter.	Pressure.
		Per cent.	Per cent.	Per cent.	Per cent.			Inches.
1	Artificial.	14·86	45·77	35·87	3·50	0·78	0·81	—
2	,,	1·52	34·01	58·55	0·94	1·50	1·51	5
3	,,	6·08	38·22	52·85	2·85	1·38	1·46	5
4	,,	8·58	31·89	57·78	1·81	1·81	1·86	2
5	Natural.	1·07	27·49	63·72	7·72	2·32	2·59	4
6	,,	5·20	29·05	42·22	23·60	1·45	2·27	1·5
7	,,	5·01	28·38	37·08	29·60	1·30	2·35	1·5
8	,,	6·00	21·70	7·63	64·67	0·35	3·33	0
9	,,	4·14	21·31	12·06	62·55	0·56	3·50	0

Notes: (1) ground brown coal; (2) ground coal from Hutton seam; (3) ground coal from Grey seam coal; (4) ground coal from Yard seam coal; (5) screen-dust from Busty seam; (6) dust from timber-baulks and haulage-road in Yard seam; (7) dust from stone in roof of Yard seam; (8) dust from top and bottom of timber-baulks and roof of Grey seam; and (9) dust from sides of haulage-roads and pillar-sides of Grey seam. As to the pressures, the length of the sealed limb of the U tube, above the level of the water in the tube, is 12 inches: a pressure of 5 inches, therefore, would represent a compression sufficient to reduce the volume of air to seven-twelfths of its original volume, and so on.

Further, the dusts were all such as would pass through a sieve with 100 meshes to the linear inch. It is scarcely justifiable to draw conclusions from the data (Table III.) furnished by these few experiments; still, attention may be directed to the influence of the proportion of volatile matter upon the inflammability and also upon the explosive character of the combustion. It may, however, be claimed that the method of examination affords a ready means of gaining information as to the character of a dust, and is also of service for the purposes of demonstration.

The authors hope to be able on a future occasion to lay before the members an account of further investigations on this important question, and meanwhile wish to express their thanks to the Council of the North of England Institute of Mining and Mechanical Engineers for the grant, which has enabled one of them to devote himself to the conduct of this work.

APPENDIX.

Dr. W. M. Thornton, Professor of Electrical Engineering in Armstrong College, has determined for the authors the resistance of the platinum wire, when heated with the currents used as described in the paper. From the data so provided, and by the aid of the coefficient of the increase of resistance with temperature of platinum as determined by Prof. H. L. Callendar, the temperatures of the coil of platinum wire, when heated by the electric currents, are as follows: 10 ampères correspond to 630° Cent., 12 ampères to 700° Cent., 15 ampères to 870° Cent., and 17 ampères to 970° Cent.

Mr. J. B. ATKINSON (H.M. Inspector of Mines) said that the members were grateful for the data which Dr. Bedson and Mr. Widdas were collecting by means of these experiments in connection with the question of coal-dust; and, when they came to the practical question of dealing with the dangers arising from coal-dust, the results already obtained, and those which they still hoped to receive, would be of the greatest service.

Mr. W. C. BLACKETT (Durham), referring to No. 2 dust (Table III.), asked whether Dr. Bedson would have expected an increasing ratio of pressure, if it had already gauged 5 inches when the dust was ignited.

Prof. HENRY LOUIS said that the experiments recorded by Messrs. Bedson and Widdas would form the basis of any future studies that might be made on the subject; and the data already collected seemed to lead to a number of valuable conclusions. They showed that roadway-dust was less dangerous than dust at the face, and that probably attention would have to be devoted almost exclusively to the dust which was being brought out with freshly hewn coals. He would like to direct the authors' attention to the state of division of the dust. He noted that all the dusts had been passed through a screen with 100 meshes per linear inch, and he was of opinion that it would be necessary to go more accurately into the question of gauge before the neces-

sary data were obtained. It would probably be found that charcoal, if excessively finely divided, would be capable of being ignited, where under ordinary conditions ordinarily fine charcoal would not ignite, and the same statement, of course, would apply to other substances. No. 5 (Table III.), a natural dust, contained a higher percentage of ash than those preceding it; it also had a much higher ratio of fixed carbon to the volatile matter, and from all previous working, as well as from other considerations, it should have been less explosive than the dust immediately preceding it, and yet the explosive power was twice as great. It was a natural dust, contrasted with artificial ones, and he would be inclined to look for the explanation of the anomaly in the fineness of the dust.

Mr. W. C. Blackett agreed that the fineness of the dust was an important consideration, and particularly the compression of the air. If the coal was reduced to very small particles it exposed comparatively a very much larger surface to be oxidized by the air, and, if the dust were submitted to a greater air-pressure, it would be more readily oxidized than at a lesser pressure. He agreed that the physical state of the dust was as important as its chemical constituents: and it was possible that an explanation of the small discrepancies in the Table might lie in the relative fineness of the dusts.

Mr. T. E. Forster (Newcastle-upon-Tyne) congratulated the authors on the results of their experiments. The question of the fineness of the dusts should be carefully noted; and particulars should be given showing the state of division of the coal. It might not be satisfactory to divide the coal into very fine dust, but it should be tested just as it was found in the mine. After all, they wanted to find out whether the dust in main roads was dangerous or not.

Dr. Bedson said, without theorizing, and only expressing his opinion, he was inclined to think that increased pressure in the glass globe would tend to increase the relative violence of the explosion. Roadway dusts were less easily inflammable, and produced smaller mechanical effects than other dusts. The fineness of the dust, was, no doubt, of very considerable importance, as well as the physical condition and the chemical composition, and he proposed, when he had the opportunity of taking up the question

of the fineness of the dusts, to submit the dusts, such as those now experimented with, to a further separation. The results obtained with No. 5 dust (Table III.) were certainly very anomalous, and the proportion of the ash was considerably higher than in the case of the artificial dusts. It was a screen-dust, and very nearly resembled No. 2 dust, obtained from the same district. Bright coal, like No. 2, was remarkable for the proportion and character of the gases enclosed in it; and the dust was specially interesting from a chemical point of view, inasmuch as it contained combustible gases which were much more readily inflammable than marsh-gas. Whether the gases contained in No. 5 coal, or the fine division of the screen-dust, afforded an explanation of its explosive character, as compared with the others in which the ratio of fixed carbon to volatile matter was much less, he could not say; no doubt it was due to the proportion as well as the nature of the volatile matter. The gases obtained from brown coal, No. 1, were very different in character and composition from those obtained from bituminous coal, and appeared to be much more readily inflammable. He did not know whether equal weights of brown coal and bituminous coal would produce exactly the same mechanical effect.

The President (Mr. J. H. Merivale), in proposing a vote of thanks to Dr. Bedson and Mr. Widdas for their paper and the interesting experiments, said that they were to be congratulated on the exceedingly effective apparatus which they had designed for the purpose of their investigations. They had designed an apparatus which was of practical service. He could speak from experience, because 25 years ago he had tried experiments on the same subject, and they were a miserable failure: partly, no doubt, owing to his want of skill, but partly also because there were not the same facilities at Armstrong College then as there were now for conducting such experiments.

The vote of thanks was heartily adopted.

Dr. John Morrow's paper on "The Strength of Cast-iron Tubbing for Deep Shafts" was read as follows:—

THE STRENGTH OF CAST-IRON TUBBING FOR DEEP SHAFTS.

By JOHN MORROW, M.Sc., D.Eng., of Armstrong College, Newcastle-upon-Tyne.

I.—Introduction.

1.—The accurate determination of the most economical form and dimensions of cast-iron cylinders, such as are used for lining deep shafts, is a matter of such great theoretical difficulty as to be, in the present state of knowledge at any rate, impossible. The best that can be done is to examine certain assumptions and to select those which, while they are useful for the purpose, are most likely to represent, at least approximately, the true state of affairs.

Much has been written on the subject, but the author is not aware of the existence of any paper giving anything like a complete statement of the problems involved. On the other hand, many theories which have been advanced are manifestly unsound, and inaccurate formulæ have been published and often accepted without criticism. Mr. Isaac Hodges* has called attention to the great disparity in the thicknesses of tubbing as calculated by the formulæ respectively due to Messrs. J. J. Atkinson, W. Galloway, G. C. Greenwell and W. Tate. The thicknesses which he himself adopted at the Methley Junction colliery were invariably greater than those given by any of these rules. Mr. H. W. G. Halbaum, and others, have also called attention to these discrepancies.

2.—It is necessary, at the outset, to define clearly the sort of structure which we propose to discuss. Actual tubbing is constructed in different ways. The chief points common to all are: the general shape is cylindrical; the tubbing is built in rings, some 2 or 3 feet in height; each ring is made up of a number of segments; and each of these segments is furnished

* "An Account of Sinking and Tubbing at Methley Junction Colliery, with a Description of a Cast-iron Dam to resist an Outburst of Water," by Mr. Isaac Hodges, *Trans. Inst. M. E.*, 1906, vol. xxxii., page 76.

with a flange running round each of its four edges, and with one or more stiffeners, parallel to each edge, intermediate between the flanges. The variable points in the design are: the flanges and intermediate stiffeners may be on the inside or on the outside of the cylindrical shell; the segments are sometimes bolted together into complete rings, and these rings may be further connected by bolts to the rings above and below them; when bolts are not used, the segments are firmly wedged together by means of wedges driven home between adjacent flanges; the segments are sometimes joined together and then turned in a lathe to ensure more accurate fitting; and the space behind the tubbing may be filled in with loose earth, or a backing may be employed of cement-concrete or other material, such as might add to the strength of the tubbing, or at least tend to prevent its collapse.

The author will always assume, unless the contrary is specifically stated, that the cross-section of the tubbing is truly circular; and also that the pressure of the water or earth on the external surface of the cylinder acts purely in a normal direction, and is of uniform intensity at all points on the circumference of any cross-section. The magnitude of the pressure is, of course, a function of the depth of the section.

Since both the vertical and horizontal joints have, under normal conditions, to transmit compressive force only, and since a departure from normal conditions (if sufficiently small) will not introduce tensile stresses, the author will assume generally that the joints are capable of transmitting stress, just as if the whole structure consisted of a single casting. When the segments are bolted together, a limited amount of tensile stress may be transmitted through the joints; but the discussion of how the transmission takes place would be long and difficult. The inability (when it exists) to transmit tensile stress ought, no doubt, to limit in some way the discussion of the resistance to collapse. Any weakness due to this cause has to be set off against the gain of stability due to the backing. A further result of this assumption is that the elasticity of the tubbing-ring may be considered to be (for small displacements) unimpaired by the joints; or rather, that the effects of the joints may be considered to be negligible.

3.—The elements of uncertainty in the problem include, in

addition to the effect of the joints between the segments of tubbing, such factors as: the lack of circularity; the rate of corrosion; the nature and amount of the external pressure; the influence of temperature-change; the unequal settlement of the curbs; and many other disturbing causes.

A large number of semi-empirical formulæ have been published at various times. They are mostly, if not invariably, based on the resistance of a cylindrical shell to compressive stresses caused by external pressure. At first sight, it would appear that such formulæ are important; but a closer investigation reveals the fact that the strength of the tubbing must depend far more upon other considerations than those upon which the theory of thin cylinders is based. It is hoped that in the present paper all the important questions are considered.

The author does not maintain that an accurate method of treatment has been discovered, or even that the theories employed are strictly applicable to the uses to which they have been put. His desire has been to bring into the field of practical mining some theories which have not been hitherto used; and, by the discussion of the applicability of these theories, to endeavour to throw some additional light on the questions concerning the sources from which cast-iron tubbing derives its strength.

4.—It has been usual to calculate the thickness, from some such formulæ as those mentioned in the last paragraph, assuming that the compressive circumferential or hoop stress is taken entirely by the cylindrical shell. The number and dimensions of the ribs appear to have been chosen arbitrarily. An accurate theory must correctly apportion the stress between the flanges, the ribs and the shell. It is frequently stated that the horizontal flanges and ribs give little or no assistance to the shell in this way. Such a statement is very different from merely saying that the stress thus borne may be neglected, as the error is on the side of safety.

In this connection, it is worth while to point out that in a segment of fairly heavy tubbing, more than one-third of the area of the face of the tubbing has behind it a thickness of metal which is greater than the nominal thickness of the shell (figs. 1 and 2, plate ii.).* The matter may be put still more forcibly, if weights instead of areas be compared. Thus, it may fre-

* *Mining*, by Prof. Arnold Lupton, 1893, page 123.

quently happen that the weight of metal having the thickness of the shell is only about one-third of the weight of the complete segment. Such considerations force the author to the conclusion that the importance which the cylindrical-shell theory has attained is quite artificial. The great sources of strength of tubbing lie, not in the shell, but in the flanges, ribs and brackets. It is in this that the tubbing problem differs so greatly from that of the boiler-flue.

5.—The function of that part of the tubbing which may be called the " plate," or " shell," is two-fold. It has to resist a portion of the hoop stress, and it has to transmit some of the external pressure to the ribs and flanges. In the former case it is subjected to compressive stresses and in the latter to bending action.

The horizontal ribs are not only stiffeners. Although this is, no doubt, their chief object, they play an important part in resisting the circumferential stresses. The formulæ for their stability is one of the novel features of this paper. The horizontal flanges perform similar duties to the ribs; but, owing to the lack of symmetry (forming the outer edges of the plate), the straining action in them is more complicated. In addition, they may be subjected to local stresses, due to the action of the wedges or bolts.

The vertical ribs and flanges are very different in their functions, and seem to be of much less importance than those which are horizontal. They transmit some of the vertical stress due to the weight of the structure; and that part of the external pressure which they receive from the shell they, in turn, transmit to the horizontal rings.

The object of the brackets is, of course, the ordinary one of increasing the lateral stability of the ribs and flanges.

6.—It is necessary, in a complete investigation, to consider a number of different ways in which the tubbing may fail. Many of these may be disposed of, once for all, as giving no trouble in practice. It is not claimed that the methods used in this paper are unimpeachable so far as mathematical accuracy is concerned; but it is hoped that when they err it is invariably on the safe side.

The customary calculation is to provide against failure under the crushing stresses, as calculated by the theory of hollow

cylindrical shells. This theory is set forth in sections 8 to 11. The resistance of a thin cylinder to collapse is dealt with in sections 15 to 19. The question is one of stability; it is associated with the elasticity, rather than with the ultimate strength, of the material.

The resistance of a circular metal ring to collapse under normal pressures is similarly considered in sections 20 and 21. The author considers this to be a sound method of calculation, from a practical point of view. When it is used, it will generally be found to be the determining factor; and, in conjunction with the formula for the bending of a metal plate, will probably suffice to complete the design.

The cylindrical surface is divided by the ribs and flanges into a number of curved plates with rectangular boundaries. The calculation of the strength of these plates, as though they were plane, is a very safe proceeding. This is done in section 22. The author, in effect, assumes that the pressure is normal to a plane surface; and, at the same time, he neglects the effect of the convexity of the plate in increasing its strength.

Section 24 deals with the stresses, in the lower rings, due to the weight of the structure.

II.—Resistance to Crushing.

7.—*Theories of Rupture.*—The greatest compressive stresses occur in the form of tangential or hoop stresses in the material of the cylinder. To calculate the thickness required to withstand these stresses safely, use can be made of a problem in the theory of elasticity, usually known as that of thick cylinders.

However, at the outset, one is confronted by an important question on which there is so far no unanimity of opinion. This difficulty—that it is not yet definitely known what it is that causes material to fracture—has an important bearing on our problem.

The matter is further complicated by the fact that the theoretical formulæ are only true, provided that the limits of elasticity are not exceeded. Indeed, when rupture is spoken of in this connection, it may be taken that, for imperfectly elastic materials such as are used in engineering constructions, one means the limit at which the material becomes damaged; and this damage may be actual fracture, excessive elongation, loss of elasticity, or some other criterion by which the value of the material may be judged. In technical works in this country

it is very generally accepted, often without question, that rupture occurs when the stress in the metal reaches some definite amount. On the other hand, there appear to be equally good reasons for the view, held by some of the most competent authorities, that the criterion of rupture is not the stress, but the tensile strain in the material. In other words, it is held that fracture occurs when the material has been stretched to the extreme limit at which it can hold together. There are still other theories. For example, Lamé supposed that rupture occurred when the tensile stress exceeded a certain limit; Coulomb assumed that the shear stress was the determining factor. Others hold that the tendency to fail is measured by the difference between the greatest and least principal stresses. Let T be the breaking stress of the material as found from tensile tests, and let E be Young's modulus. On the greatest tensile-stress theory, the tensile stress must be nowhere greater than T. On the tensile-strain hypothesis, the tensile strain must nowhere exceed $\frac{T}{E}$.

For a simple tie-bar there is no difficulty; but, in a more complex problem (such as that now under consideration), the different theories lead to different expressions for the safe load or for the thickness of metal required.

It is beyond the scope of this paper to discuss these theories. All that can be done is to find the values of the stresses and strains, and to assume that the designer wishes the greatest compressive stress limited to within a certain amount.

8.—*Thin Cylinders.*—The method of computing the strength of a thin cylinder, on the assumption that the stress is uniformly distributed, is well-known. It is given in this paragraph merely as an introduction to the more accurate solution which follows. Let p_0, r_0 be the external and p_1, r_1 the internal pressures and radii, and t (equals $r_0 - r_1$), the thickness of metal; let pressures be taken as positive and tensions as negative quantities, and so call q the hoop compressive stress in the material. The total pressure on the outside, resolved on the diametral plane, is $2p_0r_0$ per unit length of the cylinder. Similarly the internal pressure is $2p_1r_1$, opposing the external pressure. The area of metal, in the unit-length, resisting the compressive force is $2t$; and hence the stress, q, called into play is given by:

$$2qt = 2p_0r_0 - 2p_1r_1 \text{ ; and } t = \frac{p_0r_0 - p_1r_1}{q}$$

gives the necessary thickness of metal if q is not to exceed a certain limit. If there is no external pressure, p_0 is zero, and

$$t=-\frac{p_1 r_1}{q},$$

the negative sign showing that q must be negative, that is, the stress is tensile. If there is external pressure only, p_1 is zero, and

$$t=\frac{p_0 r_0}{q}.$$

9.—*Thick Cylinders.*—The stresses in a thick cylinder have been computed in various ways, but the following is the only simple method that is not open to serious objection. Let fig. 3 (plate ii.) represent a cross-section of the cylinder, and let r_1 r_0 be the internal and external radii as before. Consider a thin cylinder of the material, of internal radius r and thickness δr. It will be subjected to a pressure on both its inner and its outer surfaces; this pressure is purely normal, and is exerted by the material in contact with the surfaces of the imaginary thin cylinder. Let the pressure on the inner of these surfaces be p and that on the outer $p+\delta p$, and let pressures be spoken of as positive stresses and tensions as negative. Then, just as in the theory of thin cylinders, if the unit-length at right-angles to the plane of the diagram be considered, the total bursting pressure resolved on the diametral plane is $2pr$; and that external to the imaginary elemental cylinder, similarly resolved, is $2\ (p+\delta p)\ (r+\delta r)$. Also, if q be the hoop stress (being positive when it is a pressure), the total force resisting compression in the elemental ring is $2q\delta r$ (since $2\delta r$ is the area of material cut by any diametral plane). Equating, just as in the thin-cylinder problem, it is found that:

$$2\ (p+\delta p)\ (r+\delta r)-2pr=2q\delta r\text{; or}$$
$$p\delta r+r\delta p+\delta r\delta p-q\delta r=0.$$

Further, since δr and δp are each very small quantities their product, $\delta r\delta p$, may be neglected, as being very small indeed compared with the other terms in the equation. Omitting this term and dividing throughout by δr, it follows, when δr is taken very small, that:

$$p+r\frac{dp}{dr}=q \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

In this equation, the values of p and q depend, of course, on the chosen value for r. That is, they vary from point to point in the material of the thick cylinder: p is the radial pressure, q is

the hoop pressure; and each is measured on unit-area. There is no stress at right-angles to the plane of the figure, that is, parallel to the axis. The dimensions in this direction are, however, altered.

Let fig. 4 (plate ii.) be an enlargement of the small shaded area in fig. 3. It represents a prism of material, originally of unit-length, at right angles to the paper, subjected to compressive stresses p and q as shown. Its length is slightly increased by these forces, and the increase is obviously proportional to $p+q$. Now, if a plane-section of the cylinder is to remain plane when the pressure is applied, the displacement, parallel to the axis, of each particle of material in the plane must be the same. That is, $p+q$ must be constant over the cross-section.

This is the assumption on which the theory is based. It is a reasonable assumption, compatible with the conditions of the problem, and thus differs from the assumptions made in the other theories proposed for thick cylinders which are still set forth in many text-books. Since $p+q$ is constant, let it be written as $2a$, where a is a constant as yet unknown

$$p+q=2a \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Using this to eliminate q from equation (1) then:

$$p+r\frac{dp}{dr}=2a-p; \text{ or}$$

$$\frac{dp}{dr}=\frac{2a}{r}-\frac{2p}{r} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

The solution of this equation is

$$p=a+\frac{b}{r^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

as may be readily seen by inserting this value of p in equation (3), and so obtaining

$$\frac{d}{dr}\left(a+\frac{b}{r^2}\right)=\frac{2a}{r}-\frac{2}{r}\left(a+\frac{b}{r^2}\right); \text{ or}$$

$$-\frac{2b}{r^3}=\frac{2a}{r}-\frac{2a}{r}-\frac{2b}{r^3}$$

which is true. Here, b is the constant of integration. It must be determined later from the special conditions of the problem. Using equation (4) with equation (2), it follows that

$$q=a-\frac{b}{r^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

These, then, are the equations which give, in the general case, the values of the radial pressure p and the hoop pressure q at any distance, r, from the axis. But these stresses cannot be numerically determined until the values of a and b are found.

10.—Let the values of the constants a and b be found for the case which corresponds most closely to that of cast-iron tubbing.

The pressure on the inner surface is zero. That is, p equals 0 when r equals r_1, and hence by equation (4)

$$0=a+\frac{b}{r_1^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Let the pressure on the outer surface be p_0. Then p equals p_0, when r equals r_0, and by equation (4)

$$p_0=a+\frac{b}{r_0^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

The simultaneous simple equations (6) and (7) being solved for a and b, it follows that:

$$a=\frac{p_0 r_0^2}{r_0^2-r_1^2}; \text{ and } b=-\frac{p_0 r_0^2 r_1^2}{r_0^2-r_1^2}.$$

These values can be inserted in equation (4), which could then be applied easily to find the intensity of the pressure p at any radius r, provided that the numerical values of p_0, r_1 and r_0 were given. It is more to the author's purpose to insert these values of a and b in equation (5). Then:

$$q=\frac{p_0 r_0^2}{r_0^2-r_1^2}\left(1+\frac{r_1^2}{r^2}\right)$$

For any value of r, the hoop stress q is thus determined.

Since this stress is greatest at the inner surface, that is when r equals r_1, let q_1 be its greatest value, and the equation becomes

$$q_1=\frac{2p_0 r_0^2}{r_0^2-r_1^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

This will be referred to as the thick-cylinder formula for external pressure only. By simple algebraical transformations, it may be written

$$\frac{r_0}{r_1}=\sqrt{\frac{q_1}{q_1-2p_0}}; \text{ or} \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

$$t=r_1\left(\sqrt{\frac{q_1}{q_1-2p_0}}-1\right) \quad . \quad . \quad . \quad . \quad . \quad (10)$$

where t is the thickness of metal.

Or, again, if it be desired to connect t with r_0

$$t=r_0\left(1-\sqrt{1-\frac{2p_0}{q_1}}\right) \quad . \quad . \quad . \quad . \quad . \quad (10a)$$

This is the form often quoted as being due to Prof. W. Aldis.

11.—Approximate formulæ for rapid calculation may be obtained as follows:

If in equation (8), r_0-t be written for r_1, then

$$q_1=\frac{p_0r_0}{t-\frac{t^2}{2r_0}}; \text{ and } t=\frac{p_0r_0}{q_1-\frac{q_1t}{2r_0}}.$$

$\frac{q_1t}{2r_0}$ can be looked upon as a small correction applied to the denominator of this expression; but since t equals p_0r_0/q_1, approximately, $p_0/2$ can be written for $q_1t/2r_0$ and then:

$$t=\frac{p_0r_0}{q_1-\frac{p_0}{2}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

If the correction $\frac{p_0}{2}$ be neglected altogether, the formula reduces to that found otherwise in section 8, namely:

$$t=\frac{p_0r_0}{q} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

The closeness with which these formulæ agree may be seen by taking, say, p_0 equal to 120 pounds per square inch, and r_0 equal to 90 inches.

The accurate formula (10a) gives, taking q as 15,000,

$$t=90\left(1-\sqrt{\frac{15000-240}{15000}}\right)=0{\cdot}724 \text{ inch.}$$

The least accurate formula (12) gives

$$t=\frac{120\times 90}{15000}=0{\cdot}720 \text{ inch.}$$

Or again, if $p=640$ pounds per square inch and $r_0=120$ inches, formula (10a) gives t equals 5·280 inches; formula (11), t equals 5·230 inches; and formula (12), t equals 5·120 inches.

Equation (11) may be recommended as simple and giving results, under all circumstances, very closely agreeing with equation (10a).

The formulæ of Messrs. G. C. Greenwell, Bodart, Charles Combes, and Chaudron are based on equation (12); that of Prof. W. Galloway is of the form (11). A constant is added to some of these formulæ to allow for imperfection in casting and for

corrosion. Mr. T. A. O'Donahue's formula is based on equation (12); but it has taken a different shape, owing to the desire to make it include a casting allowance that should decrease as the pressure increases. The rule given by Prof. J. H. Merivale is (10*a*) with the inclusion of a factor of safety of 10; that due to Mr. G. H. Hollingworth is a modification of Mr. G. C. Greenwell's.

12.—In the more general case, there is an internal pressure p_1, in addition to the external pressure p_0.

Then, since p equals p_1 when r equals r_1:

$$p_1 = a + \frac{b}{r_1^2}$$

and since p equals p_0 when r equals r_0:

$$p_0 = a + \frac{b}{r_0^2}.$$

These give:

$$a = \frac{p_0 r_0^2 - p_1 r_1^2}{r_0^2 - r_1^2}; \text{ and } b = r_0^2 r_1^2 \frac{p_1 - p_0}{r_0^2 - r_1^2};$$

and equation (5) becomes

$$q = \frac{r^2 (p_0 r_0^2 - p_1 r_1^2) - r_0^2 r_1^2 (p_1 - p_0)}{r^2 (r_0^2 - r_1^2)};$$

hence

$$q_1 = \frac{2 p_0 r_0^2 - p_1 (r_0^2 + r_1^2)}{r_0^2 - r_1^2} \quad . \quad . \quad . \quad . \quad . \quad (13)$$

If this expression is negative, it means that the stress is tensile. Let f_1 be the greatest circumferential tensile stress; then f_1 equals $-q_1$, that is:

$$f_1 = \frac{p_1 (r_0^2 + r_1^2) - 2 p_0 r_0^2}{r_0^2 - r_1^2} \quad . \quad . \quad . \quad . \quad . \quad (14)$$

If, in equations (13) or (14), it is assumed that p_1 equals 0, the result of the preceding paragraph is obtained. If it be assumed that p_0 equals 0, the usual formula for thick cylinders subjected to internal pressure only, is obtained.

13.—*Other Theories of the Thick Cylinder.*—Other methods of estimating the greatest stress in a thick cylinder have been used. The theoretical basis of some of these is here briefly set forth, and the chief objections to them are indicated. The formulæ are generally given for cylinders under internal pressure only, but attempts have been made to adapt them to external-pressure problems. It is the more necessary to describe these theories, as the modified formulæ given elsewhere are often erroneous.

Taking first the theory which supposes that the thickness of

the cylinder remains constant when the pressure is applied, the cylinder must be imagined to be built up of a number of concentric elemental rings of thickness δr and of unit-length parallel to the axis. When the external and internal pressures are applied, the circumferential increase of length of all the elemental layers will be the same. If this increase be λ, then the strain in a ring of radius r will be $\frac{\lambda}{2\pi r}$; the stress, with the same notation as before, is q, and by the definition of Young's modulus of elasticity (E), it follows that

$$q=\frac{E\lambda}{2\pi r} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (15)$$

The circumferential force in each ring is $q\delta r$ and the total resistance to compression, in unit-length, becomes $2\int_{r_1}^{r_0} q dr$. Consequently

$$2(p_0 r_0 - p_1 r_1)=2\int_{r_1}^{r_0} q dr$$

whence, substituting for q from equation (15) and integrating:

$$p_0 r_0 - p_1 r_1 = \frac{E\lambda}{2\pi} \log_e \frac{r_0}{r_1}.$$

For external pressure only, writing q_1 for the greatest stress, this gives:

$$\log_e \frac{r_0}{r_1}=\frac{p_0 r_0}{q_1 r_1}; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (16)$$

and the stress at any other radius may be most easily found from the relation:

$$qr=\text{constant}.$$

Equation (16) has no advantage in simplicity of practical application, and it is based on an assumption which is known to be untrue. Moreover, equation (15) is not a correct statement. The strain $\frac{\lambda}{2\pi r}$ is due to the normal compressive force, as well as to the circumferential stress; and it is only this latter part that can be divided into the stress q to obtain the modulus E.

14.—In the previous paragraph, it was assumed that the thickness of the cylinder remained constant. Another assumption is that the sectional area does not alter. The foundation of a theory on this basis was due to Prof. Barlow.

Suppose that, after the pressure is applied, the radii r_1 and r_0 become $r_1+n_1 r_1$ and $r_0+n_0 r_0$. It will readily be seen that n_1 and

n_0 are the circumferential strains of the inner and outer surfaces. Since the sectional area does not alter:

$$\pi(r_0^2-r_1^2)=\pi[(r_0+n_0r_0)^2-(r_1+n_1r_1)^2];$$

and, neglecting n^2 as a very small quantity, this reduces to:

$$\frac{r_1^2}{r_0^2}=\frac{n_0}{n_1}.$$

Putting the stress proportional to the strains, then:

$$\frac{n_0}{n_1}=\frac{q_0}{q_1}; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (17)$$

$$\text{and } \frac{r_1^2}{r_0^2}=\frac{q_0}{q_1}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (18)$$

This relation may be written

$$qr^2=\text{constant} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (19)$$

The total force in a ring of unit-length parallel to the axis is, as before:

$$2\int_{r_1}^{r_0}qdr=2q_1r_1^2\int_{r_1}^{r_0}\frac{1}{r^2}dr=2q_1r_1^2\left(\frac{1}{r_1}-\frac{1}{r_0}\right)=2q_1r_1\left(1-\frac{r_1}{r_0}\right).$$

Equating this to the external force:

$$p_0r_0=q_1r_1\left(1-\frac{r_1}{r_0}\right), \quad . \quad . \quad . \quad . \quad . \quad . \quad (20)$$

from which the thickness may be found.

In terms of q_0, equation (20) takes the simple form:

$$p_0r_1=q_0t;$$

and the stress at any other radius may be found from equation (19).

If the radii be known, the greatest stress produced by a given pressure is:

$$q_1=\frac{p_0r_0^2}{r_1t}.$$

If, in this equation, r_1 were the mean radius, it would agree with the more accurate theory of equation (8). The assumption that the sectional area does not change is, however, unjustifiable; and the statement involved in equation (17), that the circumferential strains depend on the corresponding circumferential stresses only, is also erroneous.

III.—Resistance to Collapse.

15.—In the investigation of the stresses in a thick cylinder under an external normal pressure p_0 two systems of stress (p and q) at right angles were found. The first system tends to increase the length of the circumference of any elementary thin cylinder into which it is imagined that the whole is divided. At the same

time, it increases the length, parallel to the axis, of any portion of such a cylinder: these effects are both very small. A third, which is larger, but still small, is the tendency to reduce the thickness of the metal. The action of the other system, the hoop-stresses q, is to increase the thickness and length parallel to the axis and to reduce the circumference.

The nett result is a slight increase in the length, accompanied by a diminution in the diameter. The cylinder remains circular, but it is of diminished radius. When the external pressure is increased, however, above a certain critical value, it becomes possible for the cylinder to bend slightly and to take up a position of which the cross-section is other than circular. To guard against failure by collapse it is necessary to limit p_0 to some value less than this critical value.

16.—The determination of the critical value is a matter of some difficulty, but considerable help may be obtained from a paper by Prof. G. H. Bryan.*

Imagine a thin cylinder of great length to suffer a deformation in two dimensions; and let the deformation consist of inextensional bending. That is, it must be such that if any line whatever be drawn on the middle surface of the cylinder, this line will remain unaltered in length after the deformation has occurred. The circular section, for example, might become elliptical; or the cylinder might have one or more corrugations running throughout its entire length.

This inextensional deformation is satisfactory for this purpose, as it seems probable that any change in the shape of the cylinder which required a stretching or compression of the material (in addition to the pure bending) would require a greater value of p_0 than that which would suffice for bending without stretch. Prof. Bryan's result is that such a deformation is possible, if:

$$p_0=\frac{2}{3}\frac{\mathrm{ER}^3}{1-\sigma^2}(n^2-1);$$

in which E and σ denote Young's modulus and Poisson's ratio for the material; R is the thickness divided by the mean diameter; n is any integer greater than 1; for the least value of p_0, when n equals 2:

$$p_0=\frac{2\mathrm{ER}^3}{1-\sigma^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (21)$$

* *Cambridge Philosophical Society Proceedings*, 1888, vol. vi., page 287.

This is an expression for the external pressure at which there can be some form of the cylinder other than circular; in other words, this is supposed to be the critical pressure at which the cylinder becomes unstable.

17.—The cylinder referred to is a plane circular one of infinite length. It is free from flanges or stiffening rings, and the effect of these has still to be considered.

Since the material dealt with is invariably cast-iron, and since the values of E and σ are rarely determined experimentally, it will be well to simplify the formula by assuming average values. Thus, taking, in pounds and inch-units, E equals 18×10^6 and σ equals $\frac{1}{4}$:

$$p_0 = 4 \times 10^7 R^3 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (22)$$

In words, the equation (22) states that a cast-iron cylinder of infinite length will not collapse unless the external pressure (in pounds per square inch) exceeds 40 million times the cube of the ratio of the thickness to the mean diameter.

As a numerical example, it will be recognized that a cylinder 1 inch thick and 100 inches in diameter would require a pressure of 40 pounds per square inch to cause collapse. This allows for no factor of safety; and the lack of homogeneity of the material, combined with the inexact circularity of the original cylinder and the somewhat uncertain nature of the theory (unconfirmed as yet by experiments on a large scale), would render a high factor of safety desirable. The theory, however, receives considerable support from the experiments so far made on pipes. Messrs. A. P. Carman and M. L. Carr* have used tubes up to 10 feet in length. They found that the portion of the length affected by collapse was generally not greater than 12 times the diameter. For values of R, such as the writer has dealt with, they found, instead of the 4 given for cast-iron in equation (22), the numbers $2\frac{1}{2}$ for brass and 5 for cold-drawn seamless steel.

18.—The cylinders used in the practical problem differ from those considered in the previous paragraphs in having horizontal flanges and stiffening rings at fixed intervals in their length. The effect of these is to reduce the effective length of the cylinder to an amount which is generally very much less than the diameter.

* "Resistance of Tubes to Collapse," by Messrs. A. P. Carman and M. L. Carr, *University of Illinois, Bulletin*, 1906, vol. iii., No. 5, pages 1-26; and paper by Mr. A. P. Carman, *Physical Review*, 1905, vol. xxi., pages 381-387.

The portion of the tubbing between one flange or ring and the next is effectively a thin cylinder with fixed ends, and a consequence of the ends being fixed is that the middle surface of the cylinder cannot take up the inextensional deformation discussed earlier. Its cylindrical shape cannot be changed without appreciable stretching of some portions of the material. The stretching would no doubt be confined to definite local regions, and the greater part of the surface would bend without extension. It is clear, too, that the less the effective length of the cylindrical shell the greater is the proportion of stretching to bending; and hence, also, the greater is the critical pressure required to make the deformation possible.

It has been shown by Prof. A. E. H. Love that for a cylinder of mean diameter, d, and thickness, t, the effective length (that is the distance between the horizontal rings) should be proportional to the geometric mean between the thickness and the diameter. This may be stated by the formula:

$$l = k\sqrt{td};$$

in which l is the vertical distance between the rings, and k is some constant to be determined by experiment.

19.—Experiments which have been made on cylinders, of which the effective length is sufficiently short to influence the results, provide various empirical formulæ. They all approximate, more or less closely, to the form

$$l = k\frac{t^2}{pd} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (23)$$

But they seldom, if ever, refer to cylinders of cast-iron.

If such a form as equation (23) be accepted, the theory of dimensions shows that the constant, k, is proportional to the first power of the coefficient of elasticity or of the strength of the material. As the problem is fundamentally one of elasticity, the equation may be written:

$$l = c\frac{Et^2}{pd};$$

and it remains to find a suitable value of the constant, c.

Sir W. Fairbairn's experiments* give, with sufficient accuracy if the thickness is not less than $\frac{3}{8}$ inch:

* "On the Resistance of Tubes to Collapse," by Mr. William Fairbairn, *Philosophical Transactions of the Royal Society of London*, 1858, vol. cxlviii., page 389; "On the Resistance of Boiler Flues to Collapse," by Prof. William Cawthorne Unwin, *Minutes of Proceedings of the Institution of Civil Engineers*, 1876, vol. xlvi., page 225; and *The Elements of Machine Design*, by Prof. William Cawthorne Unwin, eleventh edition, 1890, part i., page 82.

$$l = 9{,}672{,}000\frac{t^2}{pd}.$$

If E for wrought-iron be taken as 30×10^6, this gives:

$$r = 0{\cdot}32 \ldots$$

Whence, for cast-iron, equation (23) becomes something like:

$$l = 5 \times 10^6 \frac{t^2}{pd}.$$

In boiler-flues, a factor of safety of 9 or 10 is allowed. For cast-iron tubbing, in the absence of further data, the factor would have to be considerably larger. The following rule might be expected to be safe:

$$l = 200{,}000\frac{t^2}{pd}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (24)$$

20.—A question which does not appear to have received sufficient attention is that of the stability of the stiffening rings. These rings must be sufficiently strong to prevent any change in the position or direction of the part of the cylindrical shell to which they are attached. Assuming this condition satisfied, it is still necessary to ensure that the rings will not collapse. The writer has already considered the collapsing of the shell on the assumption that the rings are sufficiently strong. The stability of the rings is quite a different question, and is a most important one.

The stability of circular rings under normal pressure has been considered by Prof. M. Lévy.* The result of his theory may be stated as follows: If x be the pressure per unit-length of the circumference of the ring, and r be the mean radius, then collapse may take place when:

$$x = \frac{3EI}{r^3}: \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (25)$$

I being the moment of inertia of the section of the ring, about a line through its centre of gravity parallel to the axis.

To apply this, a complete ring of tubbing (assuming the vertical joints capable of transmitting stress) might be taken, and its moment of inertia to satisfy the above formula might be calculated.

A more severe test is to take that portion only of the tubbing ring which may be considered to form part of the effective area

* *Journal de Mathématique*, Liouville, 1884, series 3, vol. x., page . See also Love's *Elasticity*, 1906 edition, page 405.

of the middle horizontal stiffening rib. In fig. 5 (plate ii), for example, AB and CD are bisected to obtain the length l. It is practically the distance apart of the rings or flanges, measured from centre to centre. Formula (25) must then be applied to a ring having the section shaded in fig. 5. If the thickness of the shell and the dimensions of the stiffening rings be settled on other considerations, the formula might be used to determine the distance apart of the rings. It may be written:

$$l=\frac{3EI}{pr^3} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (26)$$

It is frequently suggested that the cylinder should not be assumed to gain in strength to resist the circumferential stresses by the addition of the rings; and, on the other hand, that the rings should not be supposed to receive any assistance from the shell. Such suggestions cannot, however, be accepted. It is perfectly clear that, in any given design, if the thickness of the shell be increased, the sectional area of the stiffening rings may be decreased, or they may be spaced at greater intervals.

21.—Let it be assumed that the thickness of the ribs is equal to that of the shell. Then, if w is the width of the stiffening ring as shown in fig. 5, the formula (26) may be said to involve the three unknown quantities w, l and t. In any given case, the writer will suppose that the pressure and the radius of the shaft are known, and to simplify numerical calculation he will take the modulus, E, equal to 18×10^6 pounds per square inch.

Of the three unknown quantities, two may be chosen arbitrarily, or some proportionality may be assumed to exist between the three. In the former case, convenient practical numerical values may be given to, say, w and l and the t may be calculated. In the latter, two such relationships may be chosen as:

$$l=at, \text{ and } w=bt: \quad . \quad . \quad . \quad . \quad . \quad . \quad (27)$$

where a and b are any numbers thought suitable.

The position of the centre of gravity of the portion under consideration (fig. 6) is given by:

$$z=\frac{lt+w^2+2wt}{2(l+w)};$$

and the required moment of inertia is:

$$I=\frac{lt^3}{12}+lt\left(z-\frac{t}{2}\right)^2+\frac{tw^3}{12}+tw\left(\frac{w}{2}+t-z\right)^2.$$

Equation (27) will reduce this to the form:

$$I=ct^4;$$

in which c has a definite value, depending on the choice of a and b. Equation (26) can then be written:

$$at=\frac{3\mathrm{E}ct^4}{pr^3} \text{ or } t=kr\sqrt[3]{p} \quad . \quad . \quad . \quad . \quad . \quad . \quad (28)$$

where k stands for $\sqrt[3]{\frac{a}{3\mathrm{E}c}}$.

If the factor of safety be F, the pressure must be multiplied by F before insertion in equation (28); or the equation may be written:

$$t=kr\sqrt[3]{p\mathrm{F}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (29)$$

The following table gives values of k for different proportions of w and l likely to occur in practice. It is based on E equals 18×10^6.

TABLE I.—VALUES OF k IN THE FORMULA $t=kr\sqrt[3]{p\mathrm{F}}$.

	$l=3t.$	$l=4t.$	$l=5t.$	$l=6t.$	$l=8t.$	$l=10t.$
$w=2t$ ...	0·00249	0·00265	0·00278	0·00290	0·00311	0·00328
$w=3t$ ...	0·00187	0·00199	0·00210	0·00218	0·00234	0·00247
$w=4t$ ...	0·00151	0·00160	0·00168	0·00175	0·00187	0·00198
$w=5t$ ...	0·00126	0·00134	0·00141	0·00146	0·00156	0·00165

IV.—OTHER FORMULÆ AND METHODS OF FAILURE.

22.—*Plate-Formula.*—Supposing that, in any example of tubbing, the ribs and flanges are sufficiently strong to perform any duties which may be required of them. There may be then complete confidence in the plate, if it has the thickness given by the formula for the strength of flat rectangular plates.

In this formula, if a, b and t are respectively the length, breadth and thickness of the plate, a being greater than b, and all being in inches; and if p be the pressure on its surface in pounds per square inch; then the greatest stress, in pounds per square inch, is given by:

$$f=\frac{1}{2}\cdot\frac{pa^4b^2}{t^2(a^4+b^4)}* \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (30)$$

If the stress be taken as 20,000 pounds per square inch, equation (30) may be used to find the necessary thickness of the plate. It takes the form:

$$t=0{\cdot}005\ a^2b\sqrt{\frac{p\mathrm{F}}{a^4+b^4}} \quad . \quad . \quad . \quad . \quad . \quad (30a)$$

* *The Elements of Machine Design*, by Prof. William Cawthorne Unwin, eleventh edition, 1890, part i., page 93; *Applied Mechanics*, by Prof. John Perry, 1897, page 326; etc.

Fig. 7 (plate ii.) shows the portion of plate to which this formula may be applied. The facts—that the external pressures, under normal conditions, converge towards the centre of the cylinder, and that the plate has a camber convex towards the load—are not taken into account in the formula (30). The result is that the plate is much stronger than the formula supposes it to be, and hence a small factor of safety may be allowed. A factor of three or four should be ample, but it must be allowed on the ultimate *tensile* strength of the material.

23.—*Hoop Stress.*—When a portion of the plate including one stiffening ring (as in section 21 and fig. 6) is considered, an estimate of the magnitude of the circumferential stress may be obtained by constructing a formula of the type ordinarily used for thin cylinders.

Thus, the resolved portion of the pressure is $2prl$ and the resistance offered by the material is $2qt\ (l+w)$. Equating these, then:

$$qt\ (l+w) = prl\ ; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (31)$$

and choosing l and w in terms of t, this expression may be reduced to:

$$t = \mathrm{K}\frac{pr}{f} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (32)$$

24.—*Stress due to Weight.*—In exceptional cases, or when the depth of the tubbing is very great and supporting curbs are not employed at intermediate points in the depth, the stress due to the weight of the tubbing itself may become appreciable. In such cases the weight should be carefully calculated. In general, however, this will be unnecessary. The stress due to weight would probably never exceed, say, $\frac{1}{4}$ ton per square inch for each hundred feet of depth. If this estimate be correct, a length of 1,000 feet of unsupported tubbing would produce a stress probably well within $2\frac{1}{2}$ tons.

When the weight is supported by curbs, situated at intervals in the depth, the stress due to this cause may be neglected.

25.—*Corrosion.*—The question of how much of the metal is eaten away or rendered valueless by corrosion is a most difficult one. Attention has recently been called to it by Mr. H. W. G. Halbaum, who very properly insists on the need for more data.

It is a question which depends so much upon local circumstances that it must be left to the designer to settle in each

individual case. When the complete dimensions of the tubbing have been settled on strength-considerations, an allowance for corrosion should be distributed all round. It appears to be distinctly advisable to remove this allowance from the contingencies covered by the factor of safety. Its amount must depend on the chemical and electrolytic capabilities of the soils and water of the district; on the length of time for which the structure is required to last; on the nature and amount of the protective covering, if any, with which the metal is coated; and, very probably, on the structure and composition of the iron itself.

The writer thinks that it is safe to say that, when the metal is unprotected, this allowance should not be less than $\frac{1}{4}$ inch. Probably few engineers would care to allow more than 1 inch.

V.—Practical Examples and Conclusion.

26.—As an example of the use of these formulæ, the writer will take a shaft 600 feet deep and 14 feet in internal diameter.

If the greatest pressure is that due to a head of 600 feet of water, it follows that:

$$p=\frac{62{\cdot}4\times 600}{144}=0{\cdot}433\times 600=260 \text{ pounds per square inch.}$$

Let the ultimate strength of the material be taken as at least 100,000 pounds per square inch in compression, and 20,000 pounds per square inch in tension.

Suppose that there are eight segments in each ring and that the height of each is 2 feet 6 inches; and that there are three vertical and three horizontal rings on each segment, in addition to the flanges. Each segment is then divided by the ribs into sixteen plates, about 15 inches long by 6 inches deep.

The plate-formula gives:

$$t=\sqrt{\frac{1}{2f}\frac{pa^4b^2}{(a^4+b^4)}}=\sqrt{\frac{260\times 15^4\times 6^2}{2\times 5{,}000(15^4+6^4)}}=0{\cdot}953 \text{ inch.}$$

This allows a factor of safety of 4, and an allowance must be made for corrosion and defects in casting.

As an alternative design, let it be supposed that there is only one horizontal and one vertical rib between the flanges. The values of a and b are then each doubled; that is, the thickness must be twice as great, or:

$$t=1{\cdot}906 \text{ inches.}$$

A design intermediate between the two might have three vertical and two horizontal ribs. The rectangles are then about 15 inches by 8 inches, and

$$t=\sqrt{\frac{260\times15^4\times8^2}{2\times5{,}000\,(15^4+8^4)}}=1{\cdot}240 \text{ inches.}$$

27. —In the previous section, the thickness of the tubbing has been calculated without reference to the dimensions of the stiffening rings. To take these into account, equation (29) must be used. If w equals $3t$, l equals $4t$, and a factor of safety of 4 be adopted, it is found (from Table I.) that k equals 0·00199, and equation (29) becomes :

$$t=0{\cdot}00199\times84\times\sqrt[3]{260\times4}=1{\cdot}690 \text{ inches.}$$

Then w equals $3t$ equals 5·070 inches, and l equals $4t$ equals 6·770 inches.

This would be a suitable design. It should be noticed that it requires a greater thickness than that given by the plate-formula in section 26.

To see the effect of changing the ratio of w or l to t, the same data as before may be taken, but l may be made equal to $3t$. Then, k equals 0·00187, and hence t equals 1·590 inches, w equals 4·780 inches, and l equals 4·780 inches. More stiffening rings are required, but the thickness of the plate and the width of the rib are reduced.

28.—The example contained in the two preceding sections is one in which the final dimensions are determined by the ring-formula. The plate-formula need not have been used if it had been known beforehand that it would give a less thickness than that required by the ring-formula. The writer will now find the dimensions of tubbing for the same shaft, when each segment is provided with one horizontal and one vertical rib only. Suppose the segments to be about 5 feet wide by 3 feet deep. Using the ring-formula, w may be made equal to $4t$; and, since the ribs are far apart, l equals $10t$. Then :

$$t=0{\cdot}00198\times84\times\sqrt[3]{4\times260}=1{\cdot}685 \text{ inches ;}$$

and w equals 6·740 inches, and l equals 16·850 inches. Now test this result by the plate formula. If the plates are 28 by 16 inches, a must be equal to 28 (the greater), and b equal to 16 inches. Then :

$$t=2{\cdot}465 \text{ inches,}$$

which is larger than before. The actual thickness must now not be less than this.

Trying the ring-formula again, take w equals $2t$ and l equals $6t$, as this will give about the right value of l. Then:

$$t = 0{\cdot}00296 \times 84 \times \sqrt[3]{4 \times 260} = 2{\cdot}740 \text{ inches};$$

w equals 5·480 inches, and l equals 16·440 inches, and it can be seen that these dimensions are satisfactory.

29.—It will be interesting now to estimate the average circumferential stress in the material in this last example.

From equation (31):

$$q = \frac{prl}{t(l+w)} = \frac{260 \times 84 \times 16{\cdot}44}{2{\cdot}74\,(16{\cdot}44 + 5{\cdot}48)} = 6{,}000 \text{ pounds per square inch,}$$

approximately.

This result is within the limits of safety.

30.—Before concluding this paper, it will be well to summarize the results, in so far as they affect the method to be adopted in most rapidly determining the dimensions of cast-iron tubbing for any given external pressure and diameter of shaft: (*a*) If the stiffening rings are to be closely spaced, use the ring-formula (29) first, and then test the result by the plate-formula (30). (*b*) If the rings are far apart, use the plate-formula (30*a*) first, and then find the size of the stiffeners by the ring-formula.

As the factors of safety used in the examples may not commend themselves to all engineers; and as, in exceptional cases or in the light of further experience, it might be desirable to modify these factors, the equations (29) and (30) have been purposely left in such a form that the designer may insert whatever factors he pleases.

It will be clear that, as given, the expressions refer to strength only, and that if an allowance is to be made for corrosion it can be applied to the results calculated as above. Such an allowance should be added to t; w and l being left unchanged.

31.—*Magnitude of the Pressure.*—The pressure which the tubbing has to withstand is usually calculated as that due to a column of water of a height equal to the depth of the tubbing. When, however, there are water-bearing strata between beds of impervious rock, it may be necessary to measure the depth of the shaft from the outcrop of the water-bearing strata.

It is perhaps possible, with certain soils, to encounter pressures greater than that due to an equal head of water. In such cases Prof. Rankine's formula may be used. Thus, if h be the depth in feet, w the weight of a cubic foot of the earth, and ϕ the

To illustrate Dr J. Morrow's Paper on "The Strength of Cast-iron Tubbing for Deep Shafts."

FIG. 1.

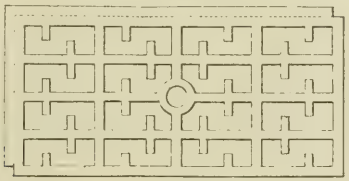


FIG. 2.

Scale, 3 Feet to 1 Inch.

FIG. 3.

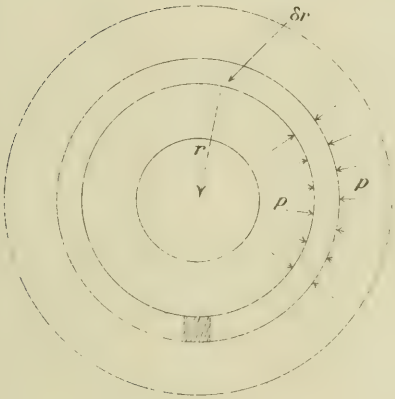


FIG. 4.

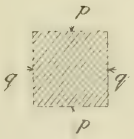
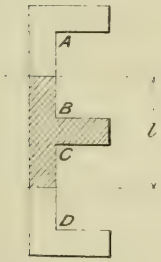
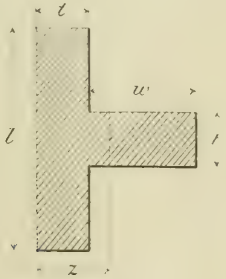


FIG. 5.



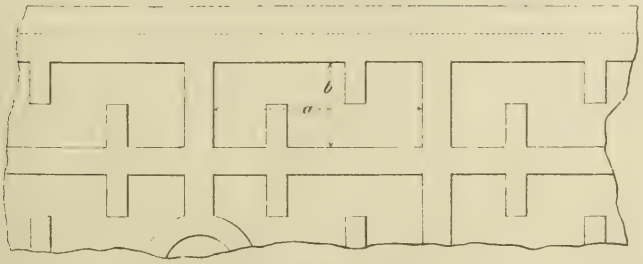
Scale, 1 Foot to 1 Inch.

FIG. 6.



Scale, 6 Inches to 1 Inch.

FIG. 7.



Scale, 1 Foot to 1 Inch.

And Reid & Company, Ltd, Newcastle-upon-Tyne

angle of repose, or friction-angle, of the earth, the pressure in pounds per square foot on the surface of the tubbing at the base is:

$$p = wh \tan^2\left(45° - \frac{\phi}{2}\right),$$

or, as it may be written,

$$p = wh \frac{1 - \sin \phi}{1 + \sin \phi}.$$

Experience with retaining walls appears to show that Prof. Rankine's theory considerably overestimates the magnitude of the pressure.

As a rough rule, it may be taken that the pressure in pounds per square inch rarely, if ever, exceeds one-half of the depth of the shaft in feet.

The President (Mr. J. H. Merivale), in proposing a vote of thanks to Dr. Morrow, said that the formulæ with which they had been familiar hitherto did not take the flanges into account.

The vote of thanks was cordially adopted.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
DECEMBER 14TH, 1907.

MR. JOHN H. MERIVALE, PRESIDENT, IN THE CHAIR.

DEATH OF MR. M. WALTON BROWN.

The PRESIDENT (Mr. John H. Merivale) alluded to the sad death of the Secretary of the Institute, Mr. M. Walton Brown, through which the members had suffered an almost irreparable loss. Sir Lindsay Wood, Bart., the senior Past-President, had hoped to be present for the purpose of moving a resolution of condolence, but had telegraphed his regret that, being detained in London, he was prevented from joining with other members of the Institute in expressing deep sympathy with the family of the late Mr. Brown in their bereavement; and in recording the great loss which the Institute had sustained in being deprived of his very valuable services. Mr. Thomas Douglas and Mr. George May, Past-Presidents, were also unavoidably prevented from being present.

Mr. A. L. STEAVENSON (Durham) moved a vote of condolence with the widow and family of the late Mr. Brown, and, in doing so, suggested that it was possible that the members would shortly have an opportunity of showing their sympathy, in a practical way, by contributing to a testimonial fund. The late Mr. Brown was a most efficient Secretary; always ready to offer any help to the members, and to afford them the benefit of his long experience.

Mr. T. E. FORSTER (Newcastle-upon-Tyne), in seconding the vote of condolence, said that, through spending so much of his time in Newcastle-upon-Tyne, he was frequently brought into contact with their late Secretary, and he was always struck with

the manner in which Mr. Brown would hunt up information and do his best to save the members trouble. They were all extremely sorry that he had been cut off so suddenly, and would, no doubt, endorse the proposal which Mr. Steavenson had foreshadowed by doing all that they could for the benefit of his widow and family.

The PRESIDENT (Mr. John H. Merivale), in putting the vote to the meeting, stated that particulars of the suggested fund would be submitted to the members at a later date.

The vote of condolence was unanimously passed by the members rising in their seats.

Mr. J. G. WEEKS (Bedlington) proposed that the Institute should procure a portrait of their late Secretary, and place it in one of the panels of the Lecture Theatre, and in so doing pay a tribute to the fidelity which Mr. Brown had shown in all his work as well as the assiduity with which he had discharged his duties.

Mr. W. O. WOOD (South Hetton), in seconding the proposal, said that the members would all agree that Mr. Brown was singularly amiable, pleasant, and agreeable, and always did his best to promote the interests of the Institute.

The proposal was unanimously adopted.

The PRESIDENT read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on November 30th and that day, together with the proceedings of the Council of The Institution of Mining Engineers at their meeting on September 4th.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. EDWARD ERSKINE BIRD, Secretary of and Engineer to Messrs. George Elliot and Company, Limited, 16, Great George Street, Westminster, London, S.W.

Mr. JAMES BOOKLESS, Mechanical Engineer, 14, Wilson Terrace, Broughton Moor, Maryport.

Mr. Charles Arthur Crofton, Colliery Manager, Wansbeck Colliery Company, Limited, Morpeth.

Mr. John Cummings, Colliery Manager, Hamsterley Colliery, Ebchester, S.O., County Durham.

Mr. William English, Colliery Manager, North Walbottle Colliery, Newburn, S.O., Northumberland.

Mr. Alan Leonard Stapylton Greenwell, Colliery Manager, Windlestone Colliery, Ferry Hill.

Mr. George Hare, Mining Engineer, Seghill Colliery, Seghill, Dudley, S.O., Northumberland.

Mr. George Hood, Colliery Engineer, 9, Agents Terrace, Boldon Colliery, S.O., County Durham.

Mr. Cecil William Jordan, Managing Director of the Goodman Manufacturing Company, Limited, Marlborough House, Marlborough Road, Roath, Cardiff.

Mr. Andrew Kerr, Colliery Manager, New Brancepeth Colliery, Durham.

Mr. George Robert Kyle, Mechanical Engineer, 6, Ravensworth Road, Dunston, Gateshead-upon-Tyne.

Mr. Frederic Thomas Marley, Mining Engineer, Damodapore Colliery, Nandi P.O., Raniganj, E.I.R., Bengal, India.

Mr. William Maurice, Mining and Electrical Engineer, The Collieries, Hucknall Torkard, Nottingham.

Mr. Charles Herman Merivale, Mining Engineer, Middleton Estate and Colliery Company, Middleton, Leeds.

Mr. Bernardino Nogara, Elecrical and Mining Engineer, Galata, Constantinople, Turkey.

Mr. Simon Pedelty, Mechanical Engineer, Broomhill Colliery, Acklington, S.O., Northumberland.

Mr. Robert McLeod Percy, Colliery Manager, Cinnamon House, Ince, Wigan.

Mr. Harry Mackenzie Ridge, Mining Engineer, Owton Manor, Seaton Carew, West Hartlepool.

Mr. Richard Summerbell, Colliery Manager, Preston Colliery, North Shields.

Associate Member—

Dr. Christoph George Sigismund Sandberg, P.O. Box 3807, Johannesburg, Transvaal.

Associates—

Mr. John Chapman, Back-overman, Tyzack Street, Edmondsley, Durham.

Mr. William Cummings, Colliery Under-manager, Beamish View, Stanley, S.O., County Durham.

Mr. Frank Daglish, Colliery Under-manager, Wilson Terrace, Broughton Moor, Maryport.

Mr. William Henry Humble, Colliery Under-manager, Seafield House, Risehow, Maryport.

Mr. Neville Blackmore Paddon, Assistant Master Shifter, Victoria House, New Delaval, Newsham, S.O., Northumberland.

Mr. Henry Anderson Ridley, Mechanical Engineer, Burnbrae, Blaydon Burn, Blaydon-upon-Tyne, S.O., County Durham.

Mr. Robert Archibald Rutherford, Colliery Engineer, Wellington Terrace, Edmondsley, Durham.

Mr. Thomas Sharp, Electrical Engineer, Wilson Terrace, Broughton Moor, Maryport.

Mr. William Thompson, Colliery Under-manager, Stone House, Broughton Moor, Maryport.

Mr. Isaac Walton, Colliery Under-manager, Dovenby, Cockermouth.

Mr. John Gilbert Widowfield, Master Shifter, Railway Terrace, Edmondsley, Durham.

Students—

Mr. John Valentine Bell, Mining Student, 226, Old Farm, Ouston, Chester-le-Street.

Mr. Douglas Roy Brooks, Mining Student, 118, York Street, Jarrow.

Mr. Edgar Walton Dakers, Mining Student, Tudhoe Colliery, Spennymoor.

Mr. Fred Herdman, Mining Student, 7, Chatsworth Parade, Low Fell, Gateshead-upon-Tyne.

Mr. August van den Honert, Mining Student, Koornmarkt, Delft, Holland.

Mr. Thomas Maughan, Mining Student, Tudhoe Colliery Office, Spennymoor.

Mr. George Henry Simpson, Mining Student, 8, Morris Street, Birtley, S.O. County Durham.

Prof. Henry Louis read the following paper "On a Deficiency in the Nomenclature of Mineral Deposits":—

ON A DEFICIENCY IN THE NOMENCLATURE OF MINERAL DEPOSITS.

By Prof. HENRY LOUIS, M.A., A.R.S.M., M.Inst.C.E., F.G.S., etc.

The object of this note is to call attention to the absence in the English language of any word or phrase to describe a phenomenon very common in certain types of ore-deposits. It is well known that the ore-shoots in a mineral vein do not, as a rule, coincide with the dip of the vein, but make an angle with it; in the same way, lenticular masses often are oblique to the direction of maximum dip of the plane in which they lie. We have no word to designate this obliquity in either case, and there seems to be a decided need of some such word which, like the German *Fallen im Feld*, shall define it without a cumbersome circumlocution. In America the term "pitch" has occasionally been applied to this obliquity of the axis of the ore-shoot or of the lenticular mass, as the case may be, and the writer wishes to propose that this word be definitely restricted in the literature of ore-deposits to this particular signification. It would thus suffice, in describing such a deposit, to give the angle and direction of the dip, followed by the angle and direction of the pitch; in both it will be understood that the angle is the angle to the horizontal, and the direction is always the azimuth of the horizontal trace of the vertical plane in which the line of dip or of pitch lies.

This suggestion has a certain practical value, and is not merely academic; every mining engineer with experience in such types of ore-deposit will have met with cases in which a vertical shaft has been sunk with the object of cutting the deposit, but has missed it, because the dip alone has been taken into account, whilst the pitch has been overlooked. It is far easier to leave out of consideration a phenomenon that has not a designation of its own, than one that is thus characterized, and that will in time come to be regularly recorded.

In conclusion, it may be pointed out that all the four characteristics—angle of dip, direction of dip, angle of pitch, direction of pitch—need not always be given fully, because a simple geometrical relation subsists between them. Thus in the subjoined diagram (fig. 1), drawn in isometric projection, let *ABCD* be the plane of the ore-deposit, and let *AC* be the axis of the ore-shoot or ore-lens; then *AD* is the strike, and *AB* the line of dip of the deposit; the angle *ABE* (=*d*) is the angle of dip, and the angle *ACE* (=*p*) is the angle of pitch; *EB* lies in the azimuth of the dip, and *EC* in the azimuth of the pitch; let the angle *CEB* between these two directions be =*a*. Then $\cos a = \frac{\tan p}{\tan d}$. This relation may occasionally prove useful.

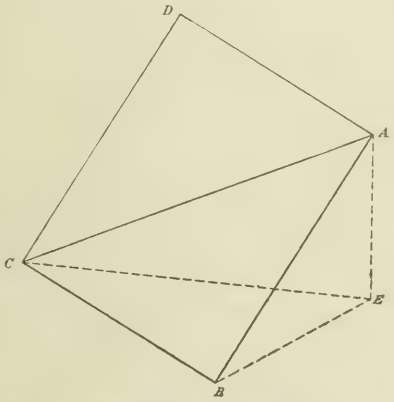


FIG. 1.—ISOMETRIC PROJECTION. DIAGRAM SHOWING DIP AND PITCH.

The writer hopes that his proposal may be found worthy of general adoption, and that to the word "pitch," in the sense here suggested, may be assigned a permanent place in the literature of ore-deposits.

Mr. T. E. FORSTER (Newcastle-upon-Tyne) said that the proposal contained in the paper was one of which anybody accustomed to metal-mining would recognize the necessity, and it seemed curious that it had never been previously put forward. The word "pitch" was sometimes used for dip. "Pitching heavily" was a phrase which meant dipping heavily, but if once the distinction were known, the term would become very useful.

Mr. WILLIAM ARMSTRONG (Wingate) agreed that the suggestion was a valuable one.

Mr. W. O. WOOD (South Hetton) said that in the coal-trade, fortunately, they were not troubled with a complication of the description indicated in the paper.

Mr. A. L. Steavenson (Durham) facetiously remarked that he did not like to allow a paper to pass without objecting to its proposals; there was not much to object to in this instance, but he hoped that they were not going to follow the example of electricians, who had adopted a great number of terms, many of them being misleading. He thought that they had better have too few than too many.

Mr. J. B. Atkinson (H.M. Inspector of Mines) said that, as regarded strike and dip, these were pretty regular and would always occur in a mineral vein, but he understood that pitch was not a regular thing; they did not have a regular deposit, but might have it waving in all sorts of shapes along the line of the vein. Personally, he did not see how the word pitch would meet the difficulty.

Prof. Henry Louis said that if a better word could be suggested he would be glad to employ it. He quite agreed that pitch was not absolutely regular, any more than dip or strike; but if a deposit was said to have a certain dip, this meant the average dip, and he proposed to use the word pitch in the same sense. They must refer to the average in all these cases, and the pitch was at least as regular as the dip in most instances.

The President (Mr. John H. Merivale) said that Prof. Louis had no doubt drawn attention to a want in mining nomenclature. It was a matter which did not come largely within their experience as mining engineers, but the same point had occurred to him as that mentioned by Mr. Atkinson. Dip was not regular; but he was under the impression that it was more regular than pitch, and that the pitch was of very little value as an indication of the position of a deposit one hundred fathoms or so away. He now understood from Prof. Louis that this was not the case, but that it was a very fair guide in searching for the deposit. He had pleasure in proposing a vote of thanks to the writer of the paper.

The vote of thanks was carried unanimously.

The following "Notes on Mining and Engineering in America and Canada" were read by Mr. Walter Rowley:—

NOTES ON MINING AND ENGINEERING IN AMERICA AND CANADA.

By WALTER ROWLEY.

In venturing a few observations suggested by a visit to America and Canada a short time ago, the writer is actuated, not by a spirit of criticism, but rather with a wish to confine his remarks to certain differences in policy, with a view to raising a discussion that may be beneficial to the members of the Institute.

American Mining Laws.—The underground officials at an American mine are styled mine foreman, assistant mine foreman, fire boss and shotlighter. Practically all the American states require an examination for the first two positions, and eight states require an examination for the position of fire boss: whilst the provinces of British Columbia and Nova Scotia require an examination for shotlighters. The position of fire boss is equivalent to that of deputy in this country, and the question is raised as to whether it would not be a step in the right direction to certificate these officials.

In Great Britain, colliery managers' and under-managers' certificates are being granted in large numbers, and for every post that is vacant there are often dozens, if not hundreds, of applicants. There is not the slightest doubt that the granting of certificates has greatly improved the class of men now in these responsible positions, and why should this not be the case with the deputies? With regard to shotlighters, the writer thinks that legislation would also be useful. Turning to surface workers, there are four states that require an examination for the post of hoisting-engineer or winding-engineman. The writer does not think that this is of any advantage. The subject suggests, however, the question of certificating our enginewrights. The extensive use of machinery in mines makes this, in the writer's opinion, desirable; and it seems as though increased efficiency would be the result of relieving a manager of some of the responsibility that he at present carries for the enginewright.

Before leaving the question of the certificated positions, it is interesting to note that some of the states issue certificates to mine foremen of two grades—one for mines where there is no gas, and others for mines which are gaseous. This has sometimes been urged in this country; but, in the writer's opinion, any man holding a responsible position should be well versed in all branches of science appertaining to the positions that he may attain. Although lack of opportunity is undoubtedly nowadays a factor to be dealt with, a man must not be educated to anticipate such a condition of affairs. Knowledge is the principal incentive to ambition, and to put a man into a position only equipped with sufficient knowledge to occupy satisfactorily that one position is to reduce his utility to the world to a minimum. Another point worthy of note is that, in the anthracite district of Pennsylvania, the miner is required to hold a certificate. This, to the writer, is of doubtful value.

With regard to the age of boys who work in mines, which in the United Kingdom is 14, it may be interesting to notice that in the anthracite mines of America the minimum age is 16. The question of age limit is largely an economic one; it seems in certain cases in America to operate with some hardship, and, indeed, a boy leaving school at, say, 13, and put to some other employment, gets into a certain routine, and it is unlikely that he would break this off to go to the mine. Of course, the obvious method is to employ boys first round about the surface of a mine, and then to draft them into the mine.

Output and Accidents in American Coal-mines.—It will, of course, be pointed out that English mines are much freer from accident than American mines, and under this head the writer would quote from a recent statement by Mr. D. W. Williams, United States Consul, Cardiff, as regards the conditions in the two countries for the year 1904*:—

	America.	United Kingdom.
Tons of coal produced	352,310,427	232,428,272
Miners employed	594,768	833,629
Number of tons per miner	593	279
Average number of days	202	262
Average daily tonnage per miner ...	2·93	1·07
Number of miners killed	1,996	1,034
Death-rate per 1,000 men	3·35	1·24
Death-rate per 1,000,000 tons	5·66	4·44

* *Mines and Minerals*, 1907, vol. xxvii., page 261.

The striking feature of this table is first, the greater number of tons produced in America per miner; and secondly, the much higher death-rate per 1,000 men employed. This increased death-rate may be due in part to the increased rate of production, but it is not wholly so, and it is interesting to note from the report, for 1906, of Mr. James E. Roderick, Chief of the Department of Mines of Pennsylvania, that, as regards mines inspection, the British mines are not subject to so much inspection as the American mines.

The following table, taken from the report, is of interest for comparison*:—

	Number of Inspectors.	Number of Mines in charge of each Inspector.	Number of employees inside of Mines in charge of each Inspector.	Production, in tons, for each Inspector.
Great Britain	38	*103	18,642	6,663,870
Pennsylvania, bituminous district	20	69	7,093	6,476,649
Pennsylvania, anthracite district	20	32	5,818	3,511,028

* In addition to these mines the inspectors have charge of all quarries.

The report of the chief inspector seems to show that the addition to the number of inspectors has not reduced the number of accidents, for, to quote his words:—"It will be necessary, therefore, to resort to some other method to bring about this greatly desired result."†

In the writer's opinion, the mining of coal is to some extent hereditary, and when it is considered that in America the output of coal was 22 tons in 1814, while in this country, at the same period, the output was upwards of 15 million tons, it will be seen that we had had a very considerable start. The increased output per miner in the United States is no doubt due to the greater average thickness of the seams, and to the easier accessibility of the coal. In some of the anthracite mines the working of the coal is more analogous to quarrying than to mining as practised in this country. In the anthracite district of Pennsylvania, out of 563 mines 355 are slope or drift mines; and in the bituminous district of Pennsylvania, out of 1,232 mines 1,070 are slope or drift mines.

* *Report of the Department of Mines of Pennsylvania*, 1906, part i., page 22.

† *Ibid.*, page 21.

Chemical Mine Fire-engine.—At the mines of the Pine Hill Coal Company, Minnesville, Pennsylvania, a chemical fire-engine (fig. 1) has been installed. The engine consists of two 60-gallon steel tanks, which are filled with a solution of soda consisting of 24 pounds dissolved in 60 gallons of water. Within the tank is a receptacle containing 12 pounds of 66-degree sulphuric acid; the chemicals being kept apart until it is desired to use the engine. When the engine is in use, the sulphuric acid is mixed with the alkaline water, causing carbon dioxide to be generated rapidly. With this engine a fire of considerable proportion can be successfully dealt with, and similar engines have been adopted at several of the large collieries.

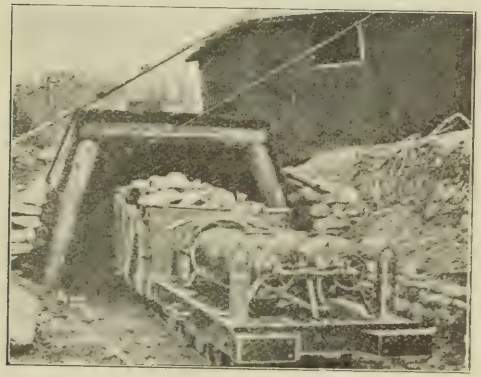


FIG. 1.—CHEMICAL MINE FIRE-ENGINE.

Supporting Excavations by Concrete.—At the Burnside colliery of the Philadelphia and Reading Coal and Iron Company, Pennsylvania, concrete arches for the support of main roads in place of timber are in use. Arches, some 18 inches square, were used to replace timber sets, 14 to 16 inches square. The design of the arches is shown in fig. 2, and the cost varied from £4 10s. to £5 10s. per arch. These arches have successfully carried the weight, which previously caused continual breakage of the

FIG. 2.—CONCRETE ARCHING AT BURNSIDE COLLIERY, PENNSYLVANIA.

timbers. There are, no doubt, cases where an extended use of concrete would be desirable for the support of excavations in English mines.

Power-stations, etc.—Montreal is being supplied with electric power from the Shawenegan Falls, which are situated on the St. Maurice river, halfway between Montreal and Quebec. The total height of the falls from the upper to the lower lake is about 140 feet, and the total available power is estimated at about 100,000 horsepower.

In designing the power-station, the chief question was whether the turbines should have a vertical or a horizontal shaft. At Niagara, as will be seen later, the turbines are placed vertically, but here the horizontal type is adopted, it being considered that it is, mechanically, more reliable. It was also decided to have a slow speed, and so the generators revolve at 180 revolutions per minute, and the current is produced at 2,200 volts. There are at present three units installed, each wheel being capable of developing 6,000 horsepower, and these are coupled to generators of the revolving-field type of 3,750 kilowatts capacity, the current being two-phase and 2,200 volts. Another unit of 10,000 horsepower is now being installed.

The transmission to Montreal is interesting; the current is transformed at the generating station up to 50,000 volts for the long distance users. The length of the line to Montreal is 85 miles, and the cables are of aluminium, the total drop in the transmission when 8,000 horsepower is being delivered in Montreal being 18 per cent. of the delivered voltage.

The use of aluminium is general for high-voltage lines. The production of this material has so rapidly increased that, although its resistance is 2·6, that of copper being 1·5, with aluminium at present prices it is the cheapest for overhead and uninsulated lines. The greater area required, however, prohibits its use for insulated cables.

Brief mention may be made of the electric power-stations at Niagara. On the American side, there are being generated by the Niagara Falls Power Company, and others, 150,000 horsepower; while developments are now in hand to give an additional 100,000 horsepower. On the Canadian side of the falls, the development is in active progress, which, when completed, will

amount to more than 400,000 horsepower, and the grand total of power then derived from the Niagara river will be about 700,000 horsepower, two-thirds of which are on the Canadian side.

The "harnessing" of Niagara seems now like ancient history; but it was only as recently as 1890 that the International Commission (of which Prof. W. C. Unwin and Lord Kelvin were members) was selected for the purpose of advising as to the best means of converting the power of the falls into electrical energy. As has already been stated, this pioneer power-station is the only one on the American side of the falls. The station has an output of 75,000 electrical horsepower. The method adopted is to tap the Niagara river above the falls by a short canal, and then to excavate a wheel pit, at the bottom of which the turbines are placed, the generators being on the surface and connected to the turbines by hollow shafts.

In the two power-houses are placed twenty-one units, each of 5,000 horsepower. The wheel pits are about 450 feet long, 18 feet wide and 180 feet deep. The current is generated, as at Shawenegan falls, at 2,200 volts, and is stepped up as required for transmission.

Three new undertakings are progressing on the Canadian side, but it is a pity to note that the capital for two of these is largely American. The designs for two of the plants are similar to those of the Niagara Falls Power Company, *i.e.*, vertical turbines. The units of these newer stations are all about 12,000 horsepower.

The works of the Ontario Development Company, which the writer visited, were in a very interesting stage. The wheel pit at the time was in course of excavation; but before any work could be done on sinking it, the coffer dam, 2,200 feet long and extending about 600 feet into the river, had to be constructed. This dam laid bare 11 acres of the river bed, its building being a most difficult undertaking; and it is creditable to the engineers that it was accompanied with the loss of only one life. The wheel pit, which is 416 feet long, 27 feet wide, and 150 feet deep, will be lined with brickwork. At the bottom of the wheel pit will be placed eleven turbines, each of a capacity of 12,500 horsepower. They are connected with generators by means of hollow steel shafting. The generators are to be of 8,000 kilowatt capacity, revolving at 250 revolutions, and delivering a three-phase current at 12,000 volts. About 1,500 feet from the generat-

ing station, the transformer house is being erected to raise the voltage to 40,000, 50,000, or 60,000 volts for transmission to the points required.

The only other feature that the writer wishes to mention is with regard to the power companies at Niagara, and that is in connection with the works of the Ontario Power Company, who are conducting the water from above the rapids by means of three main conduits, 18 feet in diameter and 6,000 feet long, buried in the ground. All the other companies have canals. and the utilization of these steel pipes, $\frac{1}{2}$ inch thick, will be watched with interest. Although in the modern designs every effort is being made to preserve the natural beauties of the falls, it is inevitable that these should suffer.

Of course, it must be borne in mind that in laying out the works for harnessing Niagara, the tunnel tail-race, feeder-canal, sluice-gates, etc., had first to be constructed up to the full ultimate capacity of the station, although only a small fraction of that amount of power could at first be utilized; consequently, it will require several years for the undertaking to grow to maturity, and, during this time, a large portion of the capital expended on the works must lie idle.

With the large power-stations in this country, however, a system of multiple units can be adopted and the plant worked under conditions of much higher initial efficiency. In almost every power-station one finds provision made for extension; the engine-house wall at one end, for instance, will be of a temporary character, so as to permit of readily extending the building and rendering the whole plant convenient for supervision, distribution, etc.

By far the greater percentage of our power in this country is, of course, obtained from the use of coal generating steam in boilers of various types, and used either in reciprocating engines or rotary turbines, and there is no doubt that a cheap coal supply is worth far more to us than would be water-power without it.

The growing use, however, of small coal for the manufacture of coke and its use in producers where ammonia, etc., is recovered, is tending to make the demand for small coal more extensive, and its price will tend to increase. Yet there is no doubt that, in many mines, particularly those in South Wales, a considerable quantity of small coal is left in the mine.

However much coal we may have, that is no reason why we should be prodigal in its use; and the writer regards the establishment of these large centres for power generation and distribution as of great economic value in the saving and conserving of our coal resources.

Time was, and to some extent still is, when by the multiplication of small power plants, not burning the coal economically, thousands of tons of coal were wasted per annum and without any useful result; but the old notion is now, the writer thinks, exploded, that because coal is cheap we can afford to waste it. In small plants that are not employed for much of their time, we not only have the losses in wasteful consumption of fuel and wasteful use of steam, but also the additional loss of interest on the money sunk in the plant which, for the greater part of its time, is idle.

If we take the extreme example of a generating station for electric lighting only, we might get a load factor of $13\frac{1}{2}$ per cent., representing 1,185 working hours at full load in the year, averaging about $3\frac{1}{4}$ hours per day. It is, of course, evident that, if we could increase the load factor, we increase the earning capacity of the plant without any addition to the capital and establishment charges. A power-station supplying several customers with varying demands can utilize a certain dovetailing which exists; for instance, arrangements can be made with a colliery customer to take power for pumping at certain hours of the day when there is not a heavy lighting load on.

It is, therefore, possible for a power-station of comparatively small capacity to supply customers with a much greater total demand. The total motors, etc., coupled up to a station might be 30,000 horsepower, but the demand might never be more than, say, 15,000 horsepower at one time.

The electric transmission of power is certainly a branch of engineering in this country which, as the coal supply becomes exhausted, must be considered more and more, and the writer ventures to think that a study of American practice will be of advantage in this particular.

Street Railways.—One great question that struck the writer with regard to the street traffic in New York and other American cities will be of interest: that traffic may be divided into three sections, (1) surface, (2) elevated, and (3) shallow subways.

The Rapid Transit Company, who have constructed the subways in New York, have, therefore, been under the wing of the Corporation instead of (as so often happens in this country) having to fight them, and to this is due the methods employed in construction, which, to an Englishman, would appear impossible, involving as they did such interruption with the street traffic. The contracting company has, the writer understands, a lease of 45 years, after which the city will become the owners. The expenditure on the new rapid transit railway was estimated to be £10,000,000. The line is 25 miles long; construction was begun in 1900, and the line was opened at the end of October, 1904.

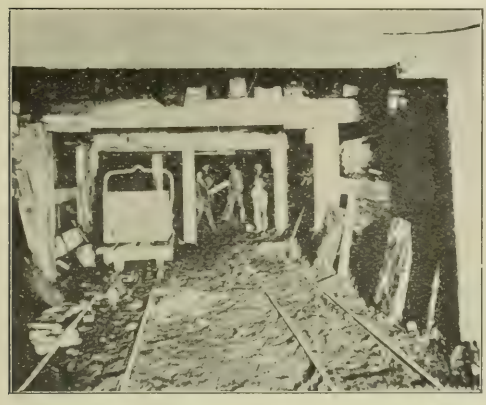


FIG. 3.—NEW YORK SUBWAY: EXCAVATION AND TIMBERING AT BROADWAY AND FULTON STREET.

The railway is not altogether underground: in some places viaducts have been built; but for the greater portion of its length the subway is at a small depth below the road level. For about half the length, the roads were opened during construction, the principal being that of "cut and cover." In New York the ground is practically rock throughout, and high buildings may be seen standing alongside the excavations with very little underpinning.

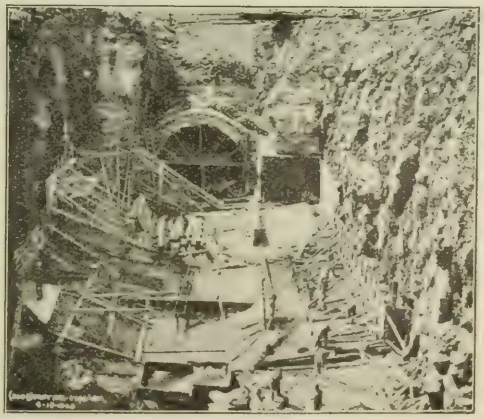


FIG. 4.—NEW YORK SUBWAY: EXCAVATION FOR STATION AT MOTT AVENUE.

Such a concession must have greatly cheapened the cost of the work of the company, but the inhabitants along the route must have suffered some disadvantage. In the busiest parts of the route, however, in the case of the deeper railways, tunnels were driven and timbered (figs. 3 and 4), similar to driving a road in a mine.

The question of foundations for the skyscrapers on route has been a very difficult one, although simplified by the rock substrata, but it has been admirably surmounted. The steel structures of these buildings enabled them to be supported by carrying columns through the basement and subway.

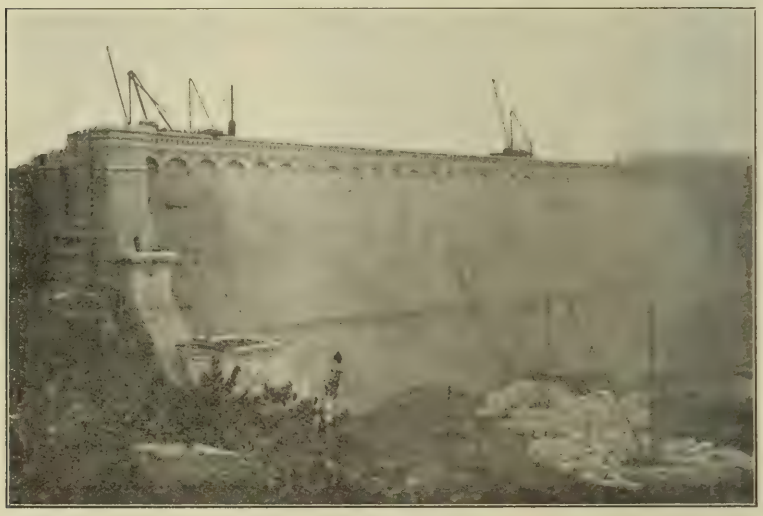


FIG. 5.—NEW YORK WATER SUPPLY: CROTON DAM.

There are about fifty-two stations in all, and it is refreshing to learn that no advertizements are to be allowed, so as to give the passenger at least a chance of finding out the name of the station before the train again starts. During the two hours when traffic is heaviest, the express trains will be able to carry 72,000 persons, and the local trains 90,000 per hour. The express trains are accommodated with a separate track over a large portion of the route.

The generating station, it is claimed, will be capable of producing more electrical power than any other in the world, and when fully equipped will have cost £1,400,000.

The power-house is 200 feet wide and 700 feet long. At present there are nine engines of 8,000 to 10,000 horsepower,

which are directly connected to 5,000-kilowatt alternators, generating energy at 11,000 volts. The total capacity of the complete station can safely be placed at 130,000 horsepower. The engines are reciprocating, and the only use of the turbines is for driving the lighting dynamos. This is possibly explained by the fact that at the time when the generating station was designed, turbines had not reached so high a state of perfection as that in which we now find them.

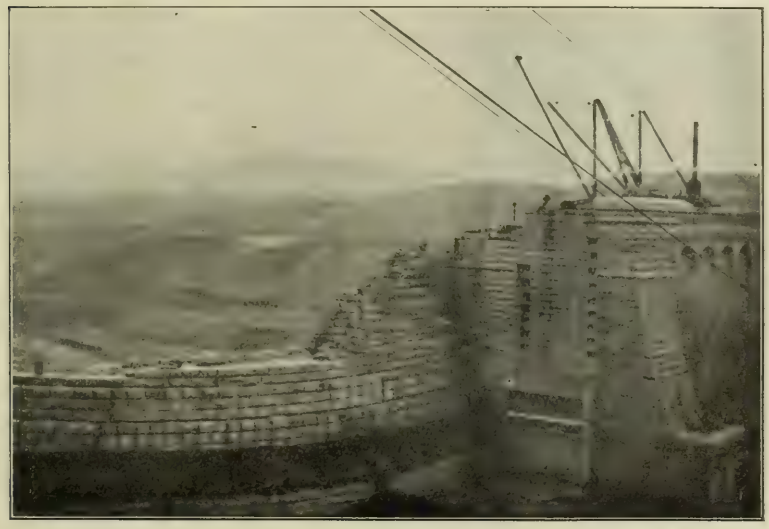


FIG. 6.—NEW YORK WATER SUPPLY: CROTON DAM, SPILLWAY.

It is interesting to note that the entire plant is designed on a unit system. Each section consists of a chimney, twelve boilers, and two engines. Each section can be disconnected from the general system by power-operated valves. Another interesting feature is, as regards the rolling stock, the admirable arrangements for safety; no sooner does the engine-driver release his hand from the lever than the brakes commence to act. The whole scheme is an admirable tribute to the capability and daring of the American engineer, who, by skill, pluck, and determination, has successfully solved this important problem.

New York Water-supply.—The water-supply of New York, a rapidly growing city, needs constant extensions in order to cope with the demand. The dam shown in fig. 5 is intended to im-

pound an additional supply of something like 30,000,000,000 gallons of water. The total height from the bottom of the footings to the top of the parapet is 297 feet, with a thickness at the bottom of 206 feet, and a thickness at the top of 18 feet.

Work on the Croton dam has been in progress for about twelve years, and it is expected to be finished very shortly. The total length of the dam is 1,168 feet, the total volume of masonry being 750,000 cubic yards. An interesting feature of the construction was the fact that considerable delay was experienced by the derricks on the top of the wall constantly having to be removed as the masonry grew up around them. This difficulty was overcome by building two steel towers, on which the derricks were placed, at a considerable height above the work. As the dam rises in height, the lower portions of the towers are enclosed and permanently built in. Fig. 6 shows the spillway of the dam.

Fig. 7.—View of Portion of Cripple Creek.

Cripple Creek Gold District (fig. 7).—Statistics are usually dry reading, but the record of this wonderful district is so remarkable that a few figures will prove interesting. Gold was first discovered here in paying quantities in 1891; within a decade it had become one of the greatest gold-producing regions of the world. In rapid development and in the richness of its ores, nothing like it has ever been known before. In ten years the cattle ranches had been transformed into a populous district of 60,000 people. The production to that date approximated £24,000,000, whilst, in 1901, it exceeded £5,000,000.

Summary.—The writer has now very rapidly presented for the consideration of the members the most important notes of his visit to America and Canada, and it only remains for him, in a

very few words, to summarize the points which impressed him most during his visit.

(1) With regard to America, his observations brought him to the conclusion that those two industries in which we are most interested, namely, coal and iron, are, without doubt, the most advanced and perfect as regards their development and arrangement. With reference to the iron trade, and the making of steel, he was particularly struck with the immense use of labour-saving appliances, which explained to him the fact that for what labour they required American factory owners and works managers were enabled to pay a high rate of wages. The development of coal in America has been distinguished by the fact that it is produced in huge quantities, and worked at shallow depths, and at comparatively moderate cost, until recently, when large requirements for coal rendered sinking to greater depths necessary.

There is one economic fact, the end of which it is difficult to forecast, that to a great extent the coal-fields are in the hands of a very limited number of people. The Pittsburg Coal Company and the Carnegie Trust each hold between 150,000 and 200,000 acres with all the underlying seams of coal of great number and thickness, and what has to be taken into consideration is the fact that such national wealth, which can never be replaced, is in the hands of so few. It is, therefore, in such articles as coal and iron-stone that the trusts command the position for controlling their production, whilst other trades have not the same means of holding their position in a monopoly.

With reference to electrical power, there can be no doubt whatever that it is more extensively used, and is much more highly developed and cheaper than in England, being in almost universal application in commercial, industrial, and private life.

(2) As regards Canada, the writer was much impressed with its prosperity as a colony and the great future before it in its agricultural and even mineral wealth, the climate being, taking it altogether, a very pleasant one.

(3) With regard to education, the writer was most favourably impressed with the fact of America having realized and responded to the necessity of educating engineers to construct and carry out their works by a thoroughly scientific training at its universities, where they acquire that theoretical knowledge which they utilize later in the practice of engineering. As a

rule, with few exceptions, the present American civil and mining engineers of eminence, and the younger men coming on, are all graduates in engineering at one or other of the universities, on which solid foundation is produced the desirable combination of the scientifically trained and thoroughly practical engineer, so beginning on a system in a new country which the old country has only just realized the necessity of: and it is to this, associated with its vast natural mineral resources, that the prosperity of America is due.

Mr. A. L. Steavenson (Durham) said the paper was a very comprehensive one, and it raised so many points, ranging from shot-firing to the falls of Niagara, that he thought the discussion should be adjourned until the members had had time to consider it. On the subject of shot-firing, it must be borne in mind that there was not only the question of a man seeing gas and understanding what it was, but the personal element came in very strongly, and the question was what the man would do if he did see gas; would he have sufficient common-sense to know what to do, and would he be capable of doing it, apart from the fact that he recognized gas when he saw it? He moved a vote of thanks to the writer of the paper.

Mr. J. G. Weeks (Bedlington) seconded the vote of thanks, and at the same time intimated that he did not agree with the writer's remarks as to the necessity for certificates for shot-firers or deputies. He thought that mining engineers in this country knew their business quite as well as those in America, and, if they were to be judged by the results as revealed in the paper with regard to safety, were even a long way ahead of them. He thought that such certificates were totally unnecessary, so far as the class of men were concerned for whom they were recommended. The certificated manager of a colliery was pre-eminently much better fitted to select suitable persons than any board of examiners, however talented or selected. So far as regarded safety of life, he did not think that their brethren in America had anything to teach them as yet.

Mr. J. B. Atkinson (H.M. Inspector of Mines) said that he was rather surprised to hear the figures as to the quantity of coal

raised in America. It was only a few years ago that the output of America had reached the total of this country. If the author's figures were correct, the advance must have been very rapid.

Mr. Walter Rowley said that it had been very rapid, but, if the figures were not right, he would be glad to be corrected; so far as he knew, however, they were so. Referring to Mr. J. G. Weeks' remarks, it was really with the intention of raising this question of certificating that the writer had offered his paper to the Institute. In his opinion, the fact of certificating officials raised the standard of the men, certainly as regards education, and doubtless many opinions would be given on this point when the final discussion on the paper took place.

Prof. Henry Louis (Newcastle-upon-Tyne) said that although he believed the statistics quoted to be correct, yet, large as the output of coal was, coal-mining in America was of secondary importance compared with metal-mining.* Any complete review of American mining matters must take cognizance of the enormous output of copper, and also of the huge output of lead, zinc, etc., not to mention the precious metals. There was a great deal to be said on many of the points raised in the paper, but it would take too long to go into them at that meeting.

The President (Mr. John H. Merivale), in putting the vote of thanks to the meeting, referred to the question of boy-labour. The author had pointed out that in America, according to law, 16 years was the age at which lads could go down the pit: but from accounts, recently published in the papers, one poor little fellow, who was only 11 years of age, suffered in a terrible accident the other day. He thought that this showed the mistake which was made in trying to legislate beyond the consciences of the persons for whom they were legislating.

The vote of thanks was cordially adopted.

---

* Since speaking, he had received the official statistics for 1906, which gave the output of bituminous coal for that year as 381,162,115 short tons (of 2,000 pounds) and of anthracite as 131,917,694 long tons (of 2,240 pounds). It was difficult to compare these figures with the total mineral production, because the output of metals as reduced from the ores was given, but it might be said that the total value of all the minerals and metals was given at 1,902½ millions of dollars (380½ million pounds sterling), out of which the value of the coals was given as 513 millions (nearly 53 million pounds sterling).

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
FEBRUARY 8TH, 1908.

MR. JOHN H. MERIVALE, PRESIDENT, IN THE CHAIR.

The ACTING SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on December 28th, 1907, January 25th, 1908, and that day; together with the proceedings of the Council of The Institution of Mining Engineers at their meetings on January 15th, 1908.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. WALTER HULL ALDRIDGE, Chief Mining and Metallurgical Engineer for the Canadian Pacific Railway, Trail, British Columbia.

Mr. UGO BAGNOLI, Engineer and Director of Monteargentario Mines, Orbetello, Italy.

Mr. JOHN CONNELL BROWN, Colliery Manager, Westport Coal Company, Limited, Denniston, New Zealand.

Mr. PERCY SIDNEY JAMES COOPER, Assistant General Manager, The North Eastern Steel Company, Limited, Middlesbrough.

Mr. CHARLES WILLIS DIXON, Colliery Manager, Westport Coal Company, Limited, Denniston, New Zealand.

Mr. RENÉ D'ENGLESQUEVILLE, Mining Engineer, 6, Rue de Mâcon, Le Creusot, Saône-et-Loire, France.

Mr. LUCIEN FRANCIS FÈVRE, Ancien Ingénieur-en-Chef des Mines, 1, Place Possoz, Paris, XVI., France.

Mr. LEWIS WARNER FOGG, Coke-works Manager, Uniontown, Fayette County, Pennsylvania, U.S.A.

Mr. JAMES JARVIE, Mining Surveyor, Kembla Heights, near Wollongong, New South Wales, Australia.

Mr. WILLIAM OUGHTON, Consulting Engineer, Milburn House, Newcastle-upon-Tyne.

Mr. Ernest Henry Potter, Mechanical Engineer, Tilmanstone Sinking-Eythorne, Dover.

Mr. William John Josiah Sandow, Mining Engineer, 17, Fenchurch Street, London, E.C.

Mr. Thomas Thomson, Colliery Manager, Westport Coal Company, Limited, Denniston, New Zealand.

Mr. Wilfrid Ingram Wrightson, Mining Engineer, Neasham Hall, Darlington.

Associate Member—

Mr. Arthur Jamieson Haggie, The Manor House, Long Benton, Newcastle-upon-Tyne.

Associates—

Mr. Charles James Fairbrother, Colliery Under-manager, Warkworth Vicarage, Warkworth, Acklington, S.O., Northumberland.

Mr. Walter Easom Goodenough, Overman, 3, Parkside, Durham.

Mr. Walter Reginald Lascelles, Surveyor, Horden, Sunderland.

Mr. James Edmund Marr, Colliery Under-manager, High Spen, Newcastle, upon-Tyne.

Mr. John Whinn, Colliery Under-manager, High Spen, Newcastle-upon-Tyne.

Students—

Mr. Oscar Earnshaw, Mining Student, Kiln Bank House, Amble, Acklington, S.O., Northumberland.

Mr. John James Turnbull, Jun., Mining Student, Cowpen Colliery Office, Blyth.

DISCUSSION OF MR. H. W. G. HALBAUM'S PAPER ON "CAST-IRON TUBBING: WHAT IS ITS RATIONAL FORMULA?"*

Mr. Frank Coulson (Durham) said that the rational formula for tubbing might apply to a certain number of cases, but the conditions in almost every case were different, and, personally, he thought that Prof. William Galloway's formula was the best, whereby the necessary strength of the tubbing was calculated, and it was left to the engineer to decide what margin to allow for strength, corrosion, etc. Mr. Halbaum intimated that the first factor was the corrosion, and if a pit was intended to last for a certain number of years, that was the factor of corrosion. They did not know, however, that the same amount of corrosion took place every year, and in his (Mr. Coulson's) opinion this was not so. He thought that it was some years before corrosion took place to any considerable extent, and probably the further it got into the cast-iron the slower was its action. Mr. Halbaum made

* *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 567.

no mention of the mixture of metal in the formula, but they all knew that certain mixtures of cast-iron were very much weaker than others; in fact, some would scarcely resist water. Mr. Halbaum seemed to think that it was quite a new thing to have a specification for tubbing; but, speaking from a knowledge extending over a period of thirty-five to forty years, he (Mr. Coulson) did not know of any tubbing made in this district without a specification giving the mixture of metal, method of making and cooling it, and the best means for testing it. If such a specification were prepared and carried out, he did not think that there was any need for an allowance for faulty castings, because it was almost impossible that there would be a faulty casting. It was suggested that the old method of tubbing with sheeting and wedges was obsolete, and that the proper method was to use bolted tubbing, packed with cement. So far as it went, that was right, but there were certain conditions when bolted tubbing would be an utter failure; and he did not know of any case where tubbing, packed up with cement in the way suggested, had been absolutely successful in keeping the pressure off the tubbing itself. It was, however, sometimes successful when allowing the water to pass up or down, but it was quite possible to meet with a pressure of water from a lower feeder very much in excess of the pressure due to the level of the water in the pit, and several accidents had occurred from that cause. Sometimes if a lower feeder, coming from a much higher source, could not pass up freely behind the tubbing and escape at the water-level in the shaft, it exerted much greater pressure on the tubbing than was expected. He had visited a place in Germany not long ago where bolted tubbing was put in, and the whole of the bottom length was blown out from the cause stated. It seemed to be taken for granted that cast-iron tubbing 2 inches thick would be twice as strong as cast-iron tubbing 1 inch thick, but this did not work out in practice. Flanges were, of course, an important factor in tubbing. He did not know whether the writer of the paper would suggest when putting in tubbing that the flanges should be of the same thickness and size, irrespective of diameter or depth. These were very important factors indeed: so much so, that it had been the practice for many years to reduce the depths of the segments from 2 feet to 18 inches, in order to get more flanges into the circle below a certain depth.

Mr. H. W. G. Halbaum (Birtley) wrote that he was pleased to see that his theoretical paper had anticipated so many of Mr. Coulson's practical objections. The author did not profess to be an authority on corrosion, nor did he at present know anyone who was. But Mr. Coulson, who had had a singularly wide experience in that direction, thought that it should be left to the practical engineer to decide the precise allowance to be made in any particular case. Well, that was the actual position adopted in the paper: the arbitrary numerical values usually employed were denounced, and it was plainly shown that the total corrosion effected during a pit's life might, according to local circumstances, be anything from zero upwards. Mr. Coulson argued that the rate might not be uniform: that corrosion was probably slower at first, quicker afterwards, and then slower again. But, on the other hand, Prof. Louis thought that the rate would be quickest of all during the first year.* But both gentlemen agreed that the author had taught that corrosion was always inevitable. Comparing their opposite views, it was manifest that one of them, at least, must be wrong with regard to the rate; whilst, with regard to the point upon which they agreed, a reference to the paper would show that both alike were wrong, as the author had never taken the position imagined. That showed, first, that these gentlemen had not examined sufficiently carefully the paper which they had criticized; and, secondly, how great was the need for that systematic collection of data which the author had urged members to supply. Until that was done, the only course open to engineers was to deal with the average rate of corrosion over a number of years, as deduced from the scanty data already obtained from a few cases where the total corrosion during a number of years was given in bulk—hence the insertion in the formula of a corrosion-member in simple terms. Those terms were rational terms, simply because they were the only terms in which the present state of knowledge permitted the quantity to be stated.

With regard to the alleged overlooking of the effect of various mixtures of metal, it could not, owing to the aforesaid lack of data, be taken into the formula as a specific term. But a very casual inspection of the paper would show that the matter had

* *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 624.

not been lost sight of, as, in enumerating the principal data required, it was distinctly suggested,* under a separate head, that the quality of the iron corroded should be included in the list.

As for the customary specifications of tubbing mentioned by Mr. Coulson, the author gladly apologized if he had inadvertently withheld credit where credit was due. But, on the other hand, he was equally pleased at last to find a point upon which he could agree with Prof. Louis, namely, that of the sheer unreasonableness of what that gentleman had called "double-barrelled specifications."

The charge, however, of taking for granted that metal of double thickness was doubly strong to resist pressure, could not be sustained against the author, since none of the formulæ, precise or approximate, propounded by him proceeded on that assumption—a fact which Mr. Coulson could easily prove for himself by subjecting the said formulæ to a few simple tests. The charge could only be sustained against the defenders of those "thin"-cylinder formulæ which the author had condemned. But, having regard to Mr. Coulson's correct attitude in that respect, it was surprising that he should declare his preference for one of those formulæ proceeding on the very assumption to which he objected—a formula, in fact, which was worse than even the ordinary "thin"-cylinder rule, since it assumed that a double thickness of metal would actually satisfy the conditions of more than the double pressure.

One portion of Mr. Coulson's criticism was not very clear. It appeared to imply that at some time or other the author had adopted the view that a cement-packing absolved the tubbing from its office of sustaining the pressure, a view which he (Mr. Halbaum) had never taken.

With regard to the bolting of the plates and the packing with cement, the writer would not think of arguing with such a redoubtable expert as Mr. Coulson the points which had been raised. He was glad that Mr. Coulson had expressed his views on the subject, as it was only men of his calibre that could be confidently expected to supply absolutely reliable information on the matter under discussion. The author, however, had to confess that

* *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 579.

he hardly understood Mr. Coulson's precise attitude towards the bolted and cement-packed tubbing. Did Mr. Coulson's objections lie chiefly against the bolts? If they did, the writer agreed with him to the extent that he did not approve of them as permanent fixtures. If Mr. Coulson did not see all that lay behind that qualification, the writer would be happy to explain, although he feared that the explanation would not immediately secure Mr. Coulson's approval. Secondly, did Mr. Coulson's objections lie chiefly against the solid cement-packing? If so, would not the same objections lie against close-topped tubbing? If not, would Mr. Coulson kindly explain, for the writer's information, why not? Mr. Coulson could be very sure that the writer was asking these questions in the most earnest and respectful spirit.

With regard to the blowing out of the tubbing at a German mine, described by Mr. Coulson, was that not clearly the result of underestimating the pressure? Was the pressure anything more than the pressure due to the head of water, measured from the outcrop of the water-bearing strata? The object of these last questions was no secret; it was to ascertain whether the blowing out of the tubbing was due to the insufficiency of the formulæ, to the bolting and packing of the tubbing, or to the oversight of the engineers. No doubt Mr. Coulson would agree that the pressures on the cement-packed tubbing should be calculated in the same way as the pressures on a close-topped tubbing, and by Rankine's formula.

Mr. Coulson had finally asked the author whether he would make all the flanges of equal thickness, irrespective of diameter or depth. Possibly Mr. Coulson intended that as a good-natured pleasantry, but whether that were so or not, the writer would respectfully reply: That in this or in any other structural design, his aim would be to erect an edifice which, from the mechanical point of view, should be symmetrical: to the best of his ability, he would aim at safety, strength, and economy, neither mistaking weakness for economy, nor extravagance for safety, nor yet confounding redundancy with strength.

Prof. W. Galloway (Cardiff) wrote that Mr. Halbaum had asked several questions in his reply to the discussion on his

(Mr. Halbaum's) paper, to which he (Prof. Galloway) might perhaps be allowed to reply as follows:—

(1) The formula given by Prof. Louis and himself was incorrect, in so far as a + was substituted for a − in the denominator.

(2) He had never proposed any other formula. He had stated that it was taken from Mr. Haton de la Goupillière's book on Mining,* but printed with the wrong sign in the denominator.

(3) Mr. Halbaum was in error when he stated that he (Prof. Galloway) desired to amend this formula further than by changing the sign in the denominator.

(4) He (Prof. Galloway) had pointed out that it was exactly the same as Mr. Halbaum's formula, when the latter was divested of the allowance for corrosion and 1 substituted for 1·6 in the second member of the denominator.

(5) The reason why he (Prof. Galloway) did not sooner correct the error of the sign in the denominator was simply that he had no occasion to make use of the formula (having ceased to lecture on the subject soon after it was published), or to compare it with the original, until its identity with Mr. Halbaum's had struck him.

(6) He (Prof. Galloway) had quoted three formulæ: Lamé's, the mathematically exact one; a second, more simple than Lamé's, but arrived at by a similar course of reasoning; and a third, derived from the second by eliminating the negligible quantity from the denominator; and he had shown that, in adopting a factor of safety of $\frac{1}{10}$, in calculating the thickness of cast-iron tubbing required in a shaft 13 feet (4 metres) in diameter at a depth of 328 feet (100 metres) below water-level, Lamé's exact formula gave 1·614 inches (41 millimetres), and the third formula, *c*, 1·575 inches (40 millimetres).† He had ventured also to state that Mr. Haton de la Goupillière, whose dictum he (Prof. Galloway) respectfully accepted, had expressed the opinion that the third formula was sufficiently accurate for all practical purposes when the use of cast-iron was in question.

(7) He (Prof. Galloway) did not claim to be the inventor of any of the formulæ, nor did it concern him how long one or other of them had been before the public, or who had quoted or con-

* *Exploitation des Mines*, first edition, 1884, vol. i., page 281.

† *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 623.

demned them in times gone by; but he would once more point out that formula (B)* constituted the essential substructure of Mr. Halbaum's "rational" formula, and that, therefore, whatever charges of incorrectness might be brought against it, the same charges applied with equal force against the so-called "rational" formula.

DISCUSSION OF DR. JOHN MORROW'S PAPER ON "THE STRENGTH OF CAST-IRON TUBBING FOR DEEP SHAFTS."†

Prof. Henry Louis (Armstrong College, Newcastle-upon-Tyne) expressed the obligations under which the members of the Institute were to Dr. Morrow for the excellent work that he had done. It was the first time that anybody had tried to work out the subject of tubbing properly and to take into account the question of ribs and flanges, which obviously played an important part; in fact, when it came to practical tubbing, he did not see how one could work out the subject without taking them into account. It was a very difficult subject, and it might be ungracious to criticize Dr. Morrow's excellent work, but he would like him to go further into detail on one point, which he thought was not quite clear. Dr. Morrow had treated the tubbing as though a ring made up of individual segments were the same thing as a continuous ring. It was obvious that with sheething and wedges, as in what he would call the English system, a ring of tubbing could not transmit forces of tension, but only forces of compression; but in the few records which he had of tubbing actually failing under pressure, as when the rings of tubbing failed when being forced down to great depths by means of hydraulic pressure in a German method of going through quicksands, in all cases it had been proved that the tubbing was squeezed oval before it gave way. A recent work by Mr. J. Riemer‡ threw some light on the subject. A ring of tubbing could not be squeezed oval unless strains of tension as well as of compression were set up. He (Prof. Louis) thought that it might be best to treat the tubbing

* *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 622.

† *Ibid.*, vol. xxxiv., page 100.

‡ *Shaft-sinking in Difficult Cases*, by Mr. J. Riemer, London, 1907.

as though each segment were a portion of an arch abutting on the other segments. Dr. Morrow stated that this was not necessary for the investigation of the subject, but he dealt with the question rather briefly; and it would be advantageous if he could elaborate the theme, and give his reasons why the arch formula was not necessary, and why the ordinary ring formula with the modifications which he had introduced could safely be employed. As regarded specifications for tubbing, referred to by Mr. Coulson, he (Prof. Louis) was rather pressing a fad of his own in suggesting that a man who wanted material of any kind, whether for tubbing or anything else, had no right to put a specification of that kind before a manufacturer. He had every right to say that he wanted, for example, cast-iron of a certain tensile strength, crushing strength, resilience, or anything else that he pleased, but surely the composition of the metal should then be left to the iron-founder. The manufacturer should be instructed that material was required which would stand up to certain definite tests; and it was the manufacturer's business to devise the composition best fitted for it. He was entirely opposed to the idea of what he might term "double-barrelled" specifications, that was, specifying the composition of the material on the one hand, and its strength on the other. The right way was to leave to the manufacturer the former, of course reserving the right of testing a certain number of pieces either to destruction or partially, in order to make sure that it did come up to the specification of strength laid down for it.

Prof. R. A. S. Redmayne (Birmingham) wrote that he was glad to find that one of the conclusions arrived at by Dr. Morrow was that there was little variation in the results of the calculations based on the different formulæ used in practice. The formula most commonly used by mining engineers was, in all probability, as follows:

$$t=r\left(1-\sqrt{1-\frac{20p}{q}}\right);$$

in which t was the thickness of the tubbing in inches; r, the external radius in inches; q, the ultimate crushing strength in pounds per square inch of the material of which the tubbing was constructed; and p, the head of water in pounds per square inch. Taking the value of q at 107,520, the thickness of the

tubbing, for a depth of 300 feet and a diameter of shaft of 12 feet, would be 1·44 inches.

If the segments were always perfectly cast, and of simple pattern, that was, without ribs, the problem of thickness would be a simple one. Any formula, in order to be trustworthy, must be conditioned by the design of tubbing-segment used, and must be based on actual experiment.

Mr. G. C. Greenwell's wellknown formula was as follows:—

$$t_1 = \frac{P_1 \times D}{50{,}000} + 0{\cdot}03;$$

in which t_1 was the thickness of the tubbing in feet; P_1, the pressure in pounds per square inch; and D the diameter in feet. It was evidently founded on, and was effective only for, the type of tubbing in use at the time at which Mr. Greenwell wrote his book.* And, so far as he (Prof. Redmayne) was aware, no single case of rupture could be attributed to insufficient thickness, in the first instance, of tubbing put in in those days: that was, tubbing of the pattern on which the formula was founded. Of course, corrosion had doubtless reduced the thickness in many cases, and had necessitated renewal on that account.

Dr. Morrow very rightly drew attention to the fact that the head of water at any one point was not necessarily that due to the vertical depth from the surface at that point; but was, in the case of water-bearing strata lying between impervious beds, the height of the outcrop of such bed above the point in the shaft, which might be very different, and necessitated a levelling being made before this factor in the calculation could be determined.

The question of great depth had seldom, if ever, come into consideration when putting in cast-iron tubbing, as the lower beds penetrated in sinkings were rarely so charged with water as to necessitate the feeders being tubbed off.

What would be of equal value to the determination of the true thickness of tubbing necessary, would be the determination of the resisting strength offered to external pressure by a column constructed of cast-iron segments of built-up and wedged tubbing, simulating, in all respects, a tubbed shaft.

Mr. C. Pilkington (Clifton) wrote that it was necessary now, when so many shafts were being sunk through water-bearing

* *A Practical Treatise on Mine Engineering*, by G. C. Greenwell, second edition, 1869, page 171.

strata, that the question of the thickness of tubbing should be thoroughly discussed. The old engineers worked out their formulæ, regarding tubbing as a plain shell, and took no count of the ribs and flanges. Had these formulæ been anything like similar, they would have satisfied most engineers, if each segment of tubbing (having regard to its thickness of metal and the diameter of the pit) had had its relative size of flanges and ribs assigned to it; but, to say that flanges and ribs did not add to the strength of the tubbing was, he thought, wrong. Dr. Morrow's plan seemed to be sound. All the formulæ only gave the thickness under normal conditions, that was, water-pressure; and extra allowances for strain, corrosive action of different waters, length of time that the tubbing had to stand, and other local conditions, were necessarily decided by reference to the local conditions of each sinking.

Prof. John Perry (Royal College of Science, London) wrote that he was inclined to think that there was not much use in applying complex mathematical theory to the question of tubbing, nor need each section be more elaborate than a flanged rectangle, 3 feet high, and of suitable length. If t was the average thickness in inches; d, the diameter in inches; p, the pressure in pounds per square inch; f, the working stress, say, 10,000 pounds per square inch; then f equalled $pd \div 2t$ was a sufficiently accurate formula in all cases. The real difficulty was that p was not known. If h was the depth in feet, then p was never so great as $5h \div 6$; and, in most cases, it was only about $h \div 20$ for any kind of earth. For rock, if liquid cement had been poured in between iron and rock, p was probably never greater than $h \div 10$. To assume that water pressed on more than very small areas was, he (Prof. Perry) thought, not right. Anyhow, it was a knowledge of the value of p that was wanted, and nobody in his position, with no practical experience of deep shafts, could do more than speculate about it.

Prof. W. Galloway (Cardiff) wrote that the impression left upon his mind after reading Dr. Morrow's admirable disquisition on this subject was that the simplest method of solving the problem of the thickness of tubbing required in any given case was as follows:—

(1) To calculate the necessary thickness at any given depth by means of formula 11 for thick cylinders (section 11),* using a factor of safety of, say, 4, or more if the nature of the ground required it.

(2) To add a minimum of $\frac{1}{4}$ inch or any intermediate thickness up to a maximum of 1 inch, that the responsible engineer might think desirable.

(3) To neglect the additional strength due to the flanges and, say, one vertical and one horizontal rib in each plate, and treat it as an "error on the side of safety." (See paragraph 1 of section 4).†

(4) To make the thickness from the upper edge of the cylinder down to the horizon at which the calculation gave a thickness of, say, 1 inch, uniform—and this depth, of course, varied inversely as the diameter.

Formula 11 was identical with that given by Prof. H. Louis and himself (see section 11),‡ except that the sign of the second quantity in the denominator was corrected and the quantity itself was divided by 2. Their formula with the correct sign was:—

$$T = \frac{WHD}{2(R - WH)};$$

in which case T was the thickness required in inches; W, the weight of a cubic inch of water; H, the height of the column of water in inches; D, the internal diameter of the shaft in inches; and R, the ultimate strength in pounds per square inch of the material employed, divided by the factor of safety. Dr. Morrow showed by calculation that, as he (Prof. Galloway) had pointed out on a former occasion, the second quantity in the denominator was so small that it might be neglected when cast-iron tubbing was in question, and that its omission made practically no difference in the calculated thickness obtained by means of what he (Dr. Morrow) claimed to be the mathematically correct formula, section 10*a*.§

The remainder of the paper was occupied with discussions on: other theories of the thick cylinder (section 13), resistance to collapse (sections 15 to 19), stability of the stiffening rings (sections 20 and 21), plate formulæ (section 22), hoop stress (section 23), stress due to weight (section 24), corrosion (section 25) and prac-

* *Trans. Inst. M. E.*, 1907, vol. xxxiv., page 109.

† *Ibid.*, page 102. ‡ *Ibid.*, page 109. § *Ibid.*, page 109.

tical results and conclusion (sections 26 to 31). Although the whole of these sections were useful in throwing light upon the general question, the only one (apart from section 25) to which he need refer in this place was section 20, in which a very useful formula (29) was given, together with a table to be used in connection with it for calculating the thickness required, on the assumption that the dimensions of the spaces between the horizontal rings and vertical ribs, and the width and thickness of the rings themselves, were determined beforehand.

Mr. H. W. G. Halbaum (Birtley) wrote that Dr. Morrow's paper required time for its adequate consideration, and, so far, he had not felt able to agree with all its conclusions; but he was very much pleased with the suggestiveness of the paper. It would be a great advantage if some gentleman could supply an historical account of the subject; but that, he supposed, would be very difficult, since, so far as he was able to gather, the early history of tubbing design, and tubbing operations, and of the earlier tubbing failures and successes, had never been written, either in fragments or otherwise. The present position was a singular one. They had a tubbing-plate of a certain design, and were endeavouring to find a formula to fit it. In the ordinary case of engineering, the formula came first and the design afterwards—or rather, the design was expressed first in the abstract formula, and then in the concrete casting. In the case of tubbing, on the contrary, they had the design already expressed in the concrete, but found the utmost difficulty in stating it in the abstract. Possibly, they would eventually design quite another kind of tubbing-plate, in which the material would be utilized to better purpose than appeared at present to be the case. He would have been pleased if Dr. Morrow had seen his way to discuss the relative merits of inside as opposed to outside flanges, etc. And if he had also discussed the effect of the ribs and brackets in accentuating the casting imperfections (for that they really did so was a matter hardly open to doubt), the value of an already valuable paper would have been enhanced.

The net results of Dr. Morrow's paper confirmed those of the paper which he (Mr. Halbaum) had already written on the same subject. They confirmed the position that if the design afforded (1) strength to resist the pressure, (2) stiffness to resist collapse,

(3) provision against corrosion, and (4) allowance for imperfect castings, it was sufficient for practical purposes.

The paper alluded to equation (10*a*) as "the accurate formula."* About that, he (Mr. Halbaum) was not very sure. Prof. A. Jamieson had stated that to construct an accurate formula for thick cylinders was simply impossible, and in his opening sentence Dr. Morrow appeared to have stated pretty much the same thing. Prof. Jamieson, moreover, stated that the most nearly accurate method was the hyperbolic method—a method adopted by himself (Mr. Halbaum), and illustrated in Dr. Morrow's formula (16). The same formula had been deduced without the aid of the calculus employed by Dr. Morrow, as would be seen by referring to Appendix III. of his (Mr. Halbaum's) paper on "Cast-iron Tubbing: What is its Rational Formula?"† Dr. Morrow stated that the hyperbolic formula (16) was based on an assumption known to be untrue. So were all other thick-cylinder formulæ, or the desired accurate solution would not be the impossibility which Prof. Jamieson and Dr. Morrow had declared it to be.

But within the limits, between which the operation of any tubbing formula must for ever be confined, the hyperbolic formula (16) "based on an assumption known to be untrue" gave practically the same results as the accurate formula (10*a*). If the stress diagrams due to the two formulæ were constructed, the area of that due to the formula (10*a*) was contained in a trapezium, whilst that of formula (16) was a hyperbolic area. The area of the trapezium was equal to the product of the length of the hyperbolic area and half the sum of the end ordinates of the hyperbolic curve. And as the hyperbolic curve obtained from any possible diagram of tubbing stresses was very nearly a straight line, it followed that the area of the one diagram very nearly equalled the area of the other. For his own part, he still thought that the hyperbolic formula (16) expressed the greater approach to accuracy, and that the formula (10*a*) was valuable inasmuch as it furnished an approximation to the truer rule (16). As a pair of rules applicable to the tubbing case, however, there was practically nothing to choose between them.

* *Trans. Inst. M. E.*, 1907, vol. xxxiv., page 109.

† *Ibid.*, 1907, vol. xxxiii., page 607.

The formula (11) was really an approximation to the hyperbolic formula (16), proceeding on the assumption that:

$$\text{Log}_e \frac{r_0}{r_1} = \frac{2\,(r_0 - r_1)}{r_0 + r_1};$$

which was very nearly true within the limits of the tubbing case, and also for some little distance beyond those limits. Dr. Morrow, however, was in error in supposing that Prof. W. Galloway's formula (whichever revision of it were taken) was of the form of equation (11). Prof. Galloway's latest rule (it was really Mr. Atkinson's) was of the form of equation (12). At no time had it ever been of the form of equation (11). Mr. Atkinson's rule was of the form of equation (12), because:

$$t = \frac{p_0\, r_0}{q_1} = \frac{p_0\, r_1}{q_1 - p};$$

because $r_0 = r_1 + t$; and it was always Mr. Atkinson's rule, until Prof. Galloway claimed it.

There was only one rule known to him (Mr. Halbaum) of the form of equation (11), and that was his own approximation to the mean of the standard formulæ quoted in his own paper. For, to quote equation (11) and reduce it, they got:

$$t = \frac{p_0\, r_0}{q_1 - \frac{1}{2}p_0} = \frac{p_0\,(r_1 + t)}{q_1 - \frac{1}{2}p_0}.$$

Therefore: $$t = \frac{p_0\, r_1}{q_1 - 1{\cdot}5\,p_0} = \frac{p_0\, r_1}{q_1 - 1{\cdot}6p}, \text{ very nearly.}$$

The last expression was the mean of the formulæ alluded to, when those were applied within the limits of the tubbing case.

The formulæ of Mr. Greenwell and others mentioned by Dr. Morrow never reposed on the bases of equations (11) and (12). Their form was expressed by the theoretical monstrosity:

$$t = \frac{p_0\, r_1}{q_1}.$$

That was to say, the thickness multiplied by the safe stress was equal to the outside pressure, p_0, multiplied by the inside radius, r_1, on which it was apparently supposed to act. Mr. Atkinson appeared to have been the only one of all the formula-makers, from Mr. Greenwell and Mr. André to Mr. Hollingworth and Mr. O'Donahue, to have grasped the fact, obvious to most people, that the outside pressure was exerted on the outside of the cylinder. Of course, the inside radius was usually the given radius, but equally, of course, if the inside radius were, for con-

venience, substituted for the outside radius in the numerator, then $(q-p)$ should be substituted for q in the denominator, so as to maintain the consistency of the natural rule which presupposed the distribution of the stress to be uniform.

Members would, therefore, see that they should not attach undue weight to Dr. Morrow's criticism of the hyperbolic formula (16). Because (*a*) it was supported as against equation (10*a*) by eminent authorities such as Profs. A. Jamieson, W. Lineham, etc.; and (*b*) because, as applied to the tubbing case, the difference of the formulæ was infinitesimal. Besides, Dr. Morrow himself had said that "Equation (11) may be recommended as simple and giving results, under all circumstances, very closely agreeing with equation (10*a*)."* And what was equation (10*a*)? It was, according to Dr. Morrow, the accurate formula. And what was equation (11), so closely agreeing with the accurate formula? He (Mr. Halbaum) would endeavour to show that very clearly, as follows:—

The hyperbolic equation (16) was:

$$\text{Log}_e \frac{r_0}{r_1} = \frac{p_0}{q_1} \frac{r_0}{r_1}.$$

But anyone could prove for himself that within the limits of the tubbing case:

$$\text{Log}_e \frac{r_0}{r_1} = \frac{2(r_0 - r_1)}{r_0 + r_1}, \text{ very nearly.}$$

Substituting this value of the logarithm in the equation (16), they got:

$$\frac{2(r_0 - r_1)}{r_0 + r_1} = \frac{p_0}{q_1} \frac{r_0}{r_1}.$$

But from the reduction of formula (12) from terms of r_0 to terms of r_1 to obtain Mr. Atkinson's formula, they knew that:

$$\frac{r_0}{q_1} = \frac{r_1}{q_1 - p_0}, \text{ very nearly;}$$

and substituting this value in the previous expression, they obtained:

$$\frac{2(r_0 - r_1)}{r_0 + r_1} = \frac{p_0 r_1}{(q_1 - p_0) r_1}.$$

But $r_0 - r_1$ equalled t, and $r_0 + r_1$ equalled $2r_1 + t$, and consequently:

* *Trans. Inst. M. E.*, 1907, vol. xxxiv., page 109.

$$\frac{2t}{2r_1+t}=\frac{p_0}{q_1-p_0};$$
$$2p_0r_1=t(2q_1-3p_0)$$

and they finally obtained:

$$t=\frac{p_0\,r_1}{q_1-1{\cdot}5p_0}.$$

This was Dr. Morrow's equation (11) reduced to terms of the inside radius, as previously pointed out. This equation, as Dr. Morrow had pointed out, could be recommended as giving results very closely agreeing with the accurate formula (10*a*). Nevertheless, it was deduced from the hyperbolic rule (16), which was, again according to Dr. Morrow, "based on an assumption known to be untrue."* For his own part, therefore, he (Mr. Halbaum) saw no real reason why anyone should renounce his faith in the hyperbolic rule (16), since even its opponents admitted that it agreed under all circumstances very closely with the accurate formula (10*a*). Especially was this so, when one remembered that even the so-called "accurate formula," along with many other formulæ, was not absolutely accurate, but only an approximation, made as carefully as the present state of knowledge permitted it to be. For example, the last value of t stated was deduced from the so-called accurate formula by Dr. Morrow, and again deduced by him (Mr. Halbaum) from the hyperbolic formula (16) which Dr. Morrow condemned.

Dr. Morrow had further stated (section 20†) that he could not accept the suggestion that the rings added nothing to the strength of the shell in tubbing structures. Perhaps Dr. Morrow misunderstood the suggestion. It referred to the natural crushing strength of the metal. The suggestion was that, if the natural crushing-strength of the metal was n pounds per square inch, then no possible number of rings could make it more than that, although the undue lack of such rings would cause the reliable safe stress to be less than the natural safe stress. The suggestion was that the rings simply restored equilibrium: a certain number of them would do that much, but no greater number could do more than that. The structure, so far as mere strength was concerned, would still be limited by the strength of its weakest part, which was the shell. In order to prevent practical men from acting upon the fallacy just pointed out, it had

* *Trans. Inst. M. E.*, 1907, vol. xxxiv., page 111. † *Ibid.*, page 116.

been found necessary to check Sir William Fairbairn's rule by a limiting-formula, the limit imposed being the natural safe crushing strength of the metal. Otherwise, for short tubes, or for tubes over-ringed, Sir W. Fairbairn's rule allowed a working-pressure which was absolutely dangerous.* Furthermore, a very high authority, Sir John Anderson, had pointed out† that surplus material in any structure whatever, so far from being a source of strength, was really a source of weakness: the effect being, not that the weaker portions transmitted their stresses to the stronger (as Dr. Morrow appeared to imply in section 5), but that these stresses concentrated themselves on the weaker portions, the result being that all the elastic work or most of it was done by the weaker parts of the structure. It was the observance of this principle which had led him (Mr. Halbaum) to recommend that, in the design of tubbing-plates, the ribs should be as few in number and as slender in bulk as might be deemed possible, having regard to the required stiffness on the one hand, to the efficiency of the castings and the distribution of the stress on the other hand. The tubbing should be stiff enough, no doubt, but it should not be forgotten that every stiffening-ring was a natural enemy to good casting and to the desired uniform distribution of the stresses in the material.

He (Mr. Halbaum) had at first been unable to identify Dr. Morrow's "plate formulæ" with Prof. W. C. Unwin's formula for rectangular plates. But, the identity being established, Prof. Unwin expressly stated that any arching or dishing of the plates altered the conditions considerably. This, of course, Dr. Morrow had admitted, but stated that the error, so far as the tubbing case was concerned, was on the side of safety. That might be true; but the object of the engineer should be to combine safety and economy, and Dr. Morrow's plate formula simply obtained the one at the expense of the other. It not only ignored the extra strength due to the curvature of the plates, but had to depend on the tensile instead of on the compressive strength of the cast-iron. Such a proceeding might be safe, but it could hardly be called by the name of practical engineering.

* *Practical Engineer Pocket-book*, 1903, page 114.

† *Strength of Materials*, pages 155 *et seq.*

The ring formula suggested for use in conjunction with the plate formula had provided him (Mr. Halbaum) with considerable food for reflection, but his present attitude was that of the open mind. The formula might perhaps be applicable to a complete ring of tubbing, but he was quite unable to perceive the economy in any design afforded by the application of formula (25) to the imaginary ⊥ ring having the section shaded in Dr. Morrow's fig. 5 (plate ii.). The thickness of the ring, so designed, would be the same as if the unshaded section of the segment were not there. Such a ring would come out in dimensions unduly extravagant. At any rate, one could not, in the absence of further information, help thinking that such would be the result.

It seemed a pity that Dr. Morrow had not, for the benefit of the members, more fully exhibited and investigated the grounds of the ring and plate formulæ. Prof. M. Lévy might be a reliable authority, and Prof. Unwin undoubtedly was, but it was not possible nowadays to accept formulæ on authority alone. Engineers were becoming increasingly desirous to understand the principles, physical and mathematical, upon which such formulæ reposed. But Dr. Morrow's two principal formulæ were hardly supported in that particular way, and until they were, one was obliged, in justice both to Dr. Morrow and himself, to hold his judgment in suspension.

In conclusion, it must not be supposed that, in offering the foregoing criticisms, he had any wish to depreciate the value of Dr. Morrow's paper. He (Mr. Halbaum) could say with perfect honesty that, in his opinion, the paper constituted a most valuable and suggestive contribution to the better understanding of an extremely difficult problem.

Mr. T. A. O'Donahue (Wigan) wrote that the mining engineer had usually disregarded the ribs and flanges when calculating the thickness of tubbing, not that he deemed them valueless, but because he considered that they might be taken to meet stresses which were too complicated for estimation. He had, therefore, had to content himself with the cylinder rule, and was of opinion that he thereby erred on the side of safety. It would appear from Dr. Morrow's paper that, for ordinary pressures, the full consideration of the plate, ribs, and flanges showed that the tubbing was considerably weaker than the cylinder rule would make

out. If the relative values of the plate and ribs could be assigned, considerable progress would be made, as there could be no question of the desirability of basing the calculation on the modulus of elasticity in preference to the ultimate strength. Without pretending to criticize the theories and deductions by which Dr. Morrow obtained his principal rule (29), the theories apparently required further confirmation, and the experiments which had been conducted might not afford an exact parallel to shaft-tubbing. That the thickness of the metal should increase only as the cube root of the pressure was too revolutionary a theory to be impulsively accepted. Practical experience counted for something; and, so far as he was aware, there had been no failures of segments where a reasonable factor of safety was allowed with the thin-cylinder rule, provided that a proper allowance was made for deterioration, and that the flanges were such as to afford a low factor of safety by the plate formula. Taking the case of the failure of tubbing at Garforth collieries, described by Mr. R. Routledge,* the tubbing in a shaft, 12 feet in diameter, was originally $\frac{3}{4}$ inch thick throughout for a length of 225 feet. The segments were 3 feet $10\frac{1}{2}$ inches long and 2 feet high, had one intermediate horizontal rib, and were badly fixed. It was fair to assume that the head of water was approximately of the height of the tubbing or, say, 110 pounds per square inch. The value of k by Dr. Morrow's rule could not be less than 0·002 for such a segment, and if the thickness of the metal were calculated by rule (29), without allowing any factor of safety, it was $[0{\cdot}002 \times 72\sqrt[3]{110} =]0{\cdot}68$ inches. When the tubbing burst, 50 years after being placed in position, the metal was said to be only about $\frac{1}{8}$ inch thick and poor in quality.

The plate formula (30) was useful to test whether the ribs and flanges were arranged sufficiently near together. The tank formula given by Sir Guilford L. Molesworth was practically identical with that given by Dr. Morrow. It was as follows:—†

$$t = \frac{a^2 b}{100}\sqrt{\frac{p}{a^4 + b^4}} + 0{\cdot}25.$$

A factor of safety of 4 was apparently allowed for in the formula, and 0·25 inch was added, doubtless for casting flaws.

* "The Garforth Collieries, with Special Reference to the Failures of the Tubbing," etc., *Trans. Inst. M. E.*, 1895, vol. ix., page 150.

† *Pocket-book of Engineering Formulæ*, twenty-fifth edition, 1907, page 314.

With regard to the width and thickness of the flange, Sir Guilford L. Molesworth gave the following formula:—(*a*) When the width (including plate) was four times the thickness of the flange:

$$t = 0{\cdot}0143\sqrt[3]{pa^2b};$$

and (*b*) when the width was five times the thickness of the flange:

$$t = 0{\cdot}0127\sqrt[3]{pa^2b}.$$

In the absence of suitable data for the allowance for corrosion, the figures (Table I.) given by Mr. B. H. Thwaite* were of interest.

TABLE I.—CORROSION OF CAST-IRON, FOR ONE YEAR'S EXPOSURE, PER SQUARE FOOT OF SURFACE.

	Metal as cast. Pounds.	Metal with Skin planed off. Pounds.	Metal with Surface Galvanized. Pounds.
Sea-water, foul	0·0656	0·2301	0·0895
,, clear	0·0635	0·0888	0·0359
River-water, foul	0·0381	0·0728	0·0371
,, clear	0·0113	0·0109	0·0048
Air, pure	0·0113	0·0109	0·0048
,, manufacturing district, or at sea	0·0476	0·0884	0·0199

Dr. JOHN MORROW (Armstrong College, Newcastle-upon-Tyne) wrote, in reply to the discussion on his paper, that Prof. Perry had called attention to the uncertainty which must always exist as to the actual magnitude of the pressure applied to the tubbing. Considering material having a friction-angle of 16 degrees and a weight per cubic foot of 130 pounds, Rankine's formula gave a pressure equivalent to $0{\cdot}51h$ pound per square inch, where h was the depth in feet. It was probable that this was an over-estimate, and it appeared unlikely that more severe conditions would ever occur. Prof. Perry was, therefore, on the safe side in saying that p was never so great as $\frac{5}{6}h$.

The values $\frac{h}{20}$ and $\frac{h}{10}$ were, however, under-estimates, if the valuable experiments recently described by Mr. Isaac Hodges† could be relied upon. In these experiments, made at Methley Junction colliery, the water-pressure found in the upper section of the tubbing agreed very closely with that given by the ordinary

* *Engineers' Handbook*, by Prof. H. Adams, page 84.

† "An Account of Sinking and Tubbing at Methley Junction Colliery, with a Description of a Cast-iron Dam to resist an Outburst of Water," by Mr. Isaac Hodges, *Trans. Inst. M. E.*, 1906, vol. xxxii., page 76.

calculation. The lower section was evidently under quite different conditions, and the observed water-pressures were less than half those obtained by calculation. The greatest depth at which the pressure was recorded was 214 feet 5 inches, and the water-pressure there was 45 pounds per square inch. This corresponded to a pressure of $0{\cdot}21h$ pound per square inch, and was much in excess of Prof. Perry's estimates. It was important to remember, as pointed out by Mr. Coulson, that several accidents had occurred owing to the pressure of water from a lower feeder being very much in excess of that due to the level of water in the pit. In this connection Prof. R. A. S. Redmayne's remark might be recalled, concerning the freedom of the lower beds from water. One of the causes of this absence of water in appreciable quantities was that the outcrop of a deeply-seated bed was usually far distant from the site of the sinking; the faults and fissures occurring in the water-bearing strata might then not only provide an excellent system of drainage, but give a new level below which the depth of water should be measured. It appeared, therefore, that, in order to acquire a more accurate knowledge of the value of p, it was necessary that a large number of observations, similar to those conducted by Mr. Isaac Hodges, should be made; and that in each case the geological conditions should be carefully considered.

It would be noticed that the author was not entirely in agreement with Prof. Perry as to the simplicity of the calculation necessary to ensure a sufficient thickness of casting, although the formula given by Prof. Perry (in which t was the average thickness) was the same as those stated more fully in the paper as formulæ (31) and (32).*

Prof. Louis had presented some difficult questions, and it would only be possible to indicate the nature of the answers. Wedged tubbing could not transmit tensile forces at the joints; but, since these joints were under pressure, it would be possible for a large variation of stress-distribution to occur without tensile stresses being thereby introduced. Further, owing to the great width of the vertical flanges (compared with the thickness of the shell), considerable tensile-stresses might occur in the castings without the stability of the joints being endangered. It ought

* *Trans. Inst. M. E.*, 1907, vol xxxiv., page 119.

not to be difficult for anyone with sufficient leisure to obtain quantitative results on this point, and such would, no doubt, be valuable.

With regard to the application of the arch theory, the position was this: If the shaft were truly circular and the pressures purely normal, a proper application of the theory of arches would give a "line of resistance" in the form of a circle passing round the tubbing-ring. This circle would, in position and direction, represent at every point the line of action of the resultant of the compressive stresses found by the thick-cylinder formula. If one tried to draw such a line in the way usual for arches, he would be easily convinced of the truth of the above statement.

When the pressure was not normal, or the ring not circular, the thick-cylinder formula was inapplicable, and the arch methods might possibly be employed: but, in his (Dr. Morrow's) paper, any appreciable deformation from the circular shape was looked upon as failure, and was, therefore, not further considered.

The difficulties of the subject were not inconsiderable, and it was perhaps advisable to point out that, in order to render the writing of the paper possible, the author had limited his investigations to the question of the strength of the castings, and had not considered the stability at the joints. If tubbing, designed by the rules laid down, were subsequently to collapse by displacement of the segments as a whole, rather than by fracture of the material, such a failure would have no bearing on the methods adopted in the paper. It might be pointed out that no theory hitherto given took into account anything but the strength of the material.

Mr. Halbaum was unfortunate in writing in defence of the logarithmic formula. At present, he (Mr. Halbaum) considered it to be the correct one; but there were no grounds whatever for such a supposition. It was not only based upon an untrue assumption, but involved an error in calculation. It was useless to maintain that such a theory ought not to be replaced by a more reliable one. It was, perhaps, worth while to point out that a formula might give excellent results when used in connection with internal-pressure problems, and yet be at fault in the case of external pressures. It must always be borne in mind that, even for cylinders under internal pressure, the only

reason why the logarithmic formula might be used was because it gave results which agreed more or less closely with the more accurate theory. The reasons why Lamé's theory might be considered satisfactory were clearly stated in the paper.

Mr. Halbaum's remarks were so lengthy that it was inadvisable to reply to them in detail. They frequently carried with them their own condemnation. In fairness to other writers to whom Mr. Halbaum referred it would be sufficient to say: (1) That although Prof. Jamieson had used the logarithmic formula for cylinders under internal pressure, he did not by any means uphold it as more accurate than the accepted theory. (2) That Prof. Lineham did not appear to have used the logarithmic formula at all, but gave (in his text book*) the correct theory for cylinders under internal pressure; that, so far as the author could ascertain, neither Prof. Jamieson nor Prof. Lineham had ever considered the external pressure problem; and that Profs. Lamé and Levy were amongst the greatest authorities on the elasticity and strength of materials. (3) That Sir W. Fairbairn's formula was for the collapse of long cylinders and was not to be mentioned in connection with short or over-ringed tubes. (4) And, finally, that Sir John Anderson had not said anything so absurd as that surplus material, in any structure whatever, was a source of weakness.

Mr. O'Donahue's contribution to the discussion was helpful, but his earlier remarks might be misunderstood. The ribs and flanges did not, of course, weaken the tubbing. The point Mr. O'Donahue brought out was that the structure frequently offered less resistance to deformation (and consequent collapse) than to actual crushing. Thus it was only when deformation was considered that the source of weakness was discovered.

The failure at Garforth collieries, in its relation to equation (29) of the paper, was to be explained on the grounds that the pressure might have been much less than 110 pounds per square inch, that the thickness might have been about $\frac{1}{8}$ inch in some places and much greater in others, and by the more important consideration that equation (29) was for the deformation of an unsupported ring, whereas in the case cited considerable support might have been forthcoming. The paper, by its title, referred mainly to "deep" shafts. There appeared

* *Text-book of Mechanical Engineering*, by Prof. W. Lineham, second edition, 1895, page 399.

to be a general consensus of opinion in favour of neglecting, for such cases, the additional strength imparted to the tubbing by the backing or by any lateral support it might receive.

The author had not noticed Sir Guilford Molesworth's formula when writing the paper, or would have referred to it. When the numerical examples were added to the paper, too much prominence was perhaps given to the plate-formula. The position taken up, as the result of the investigation, was that the formulæ (11), (24), (29), and (32) should be satisfied for deep shafts. Of these, (29) would usually be the determining factor: but, in unusual designs, it might be necessary to test the result by the others. The plate-formula (30*a*) was an additional safeguard, but one which, in the author's opinion, need only be applied under exceptional circumstances. If the designer were afraid that the pressure might not be normal to the outer surface of the shell, he might apply formula (30*a*). Or, again, if the tubbing segments were to be constructed to withstand a "squeezing pressure" of the earth (or strata) of any definite amount, formula (30*a*) should be a safe formula to use.

Section 7 of his (Dr. Morrow's) paper* dealt briefly with the different theories of rupture; but the succeeding sections were based on the assumption that the compressive stress was to be kept within a safe limit. Since writing the paper, he had noticed a simplification which occurred on another assumption as to the cause of failure. Thus, if it were desired to design the cylinder so that the greatest compressive strain was limited to some definite amount, the formulæ would be exactly the same as those already given in section 10.† This might be seen from equation (8); q was the whole stress at the inner surface of the cylinder, since p was zero there; and, hence, if q was the stress which, in a simple compressive (or tensile) test, would produce the limiting value of the strain, the formula (8) still held good. This was, of course, not by any means true for a cylinder subjected to internal pressure; and, although capable of rigid proof, the above statement hardly amounted to a complete demonstration. This result would also serve to illustrate how wrong it was to take a formula obtained for cylinders under internal pressure

* *Trans. Inst. M. E.*, 1907, vol. xxxiv., page 104.

† *Ibid.*, page 108.

and to endeavour to amend it to suit the external-pressure problem. The formula due to Grashof, and erroneously altered by Mr. Halbaum,* was evidently based on a strain-theory of rupture, and was, in the form given, quite inapplicable to the tubbing problem.

He felt that the value of the paper had been materially enhanced by the remarks and suggestions which it had elicited: and, in conclusion, he would like especially to thank Prof. H. Louis, who had first called his attention to the fact that a complete re-examination of the methods of calculating the strength of tubbing was required, and who had given him much assistance in the preparation of the paper.

The PRESIDENT (Mr. John H. Merivale) said that the members were very much indebted to Dr. Morrow and Mr. Halbaum for attempting to treat this very practical subject from a theoretical point of view. There were, however, some subjects so essentially practical that it was almost impossible to treat them theoretically.

DISCUSSION OF PROF. HENRY LOUIS' PAPER ON "A LOCKING HOOK FOR SINKING PURPOSES."†

Mr. FRANK COULSON (Durham) said that the sketches of spring hooks in both the paper and the discussion were very misleading, and wrong in construction. It was a good idea to have a spring hook locking, but he did not know of many accidents having occurred with an ordinary properly-constructed spring hook. He had known one case where a kibble came up on the point of the hook, but that was due to carelessness, and ought not to have occurred. There was only one position in which a hook could become detached, and that was when the load was resting. Better than a spring hook was a hook having a hole through the tongue, with a similar hole through the end of the hook, and a leather thong to put through (figs. 1 and 2). This was one of the best and safest appliances: there was necessarily no spring to break, although a spring might be used, and would generally last for many months,

* "Cast-iron Tubbing: What is its Rational Formula?" by Mr. H. W. G. Halbaum, *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 596.

† *Trans. Inst. M. E.*, 1907, vol. xxxiv., page 56.

and it could be quickly handled. With a locking hook, there was a certain amount of danger of the tongue lifting when it became slightly worn.

Prof. H. Louis said he considered that Mr. Coulson's remarks constituted an argument in favour of such a contrivance as was described in his paper; for he (Mr. Coulson) had stated that some accidents had occurred, and it was because there was nearly an accident in a sinking with which he (the speaker) was

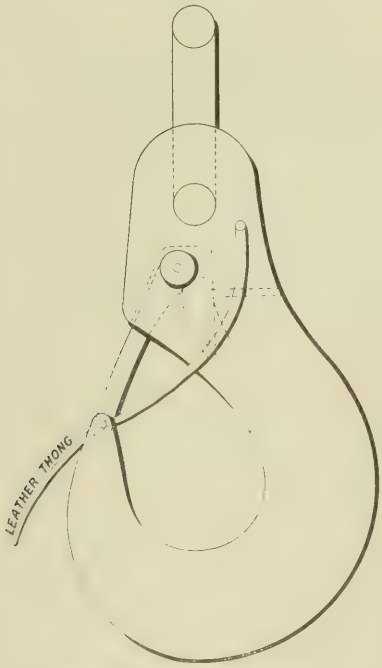


Fig. 1.—Safety Hook with Leather Thong. Scale, 6 inches to 1 inch.

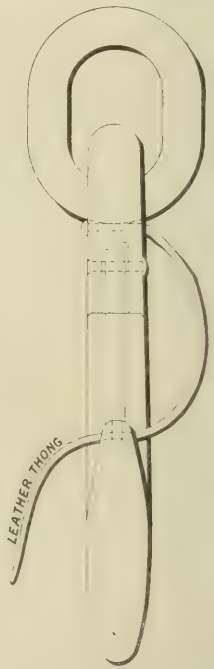


Fig. 2.—Safety Hook with Leather Thong. Scale, 6 inches to 1 inch.

connected, that the idea occurred to him. The kibble came away from the hook; but, fortunately, the sinkers in the pit-bottom managed to get out of the way in time. If such an appliance as he had described would prevent a single life from being lost, it was worth adopting. His form of hook had been in use for over six months, and seemed to answer well. Personally, he agreed with the idea of the leather thong, if they could have a conscientious man to stand over the sinkers and see that they tied it every time;

but what he wanted was something that would work automatically, whether the men were careful or careless.

Mr. T. C. Futers (Whitley Bay) asked how the kibble got off the hook, if, as he understood, the load was being lifted at the time. With an elongated section, instead of round, it would be easily understood.

The President (Mr. John H. Merivale) also asked how the kibble managed to come up on the point of the hook. Of course, if it could slide on to the point, it could equally slide off it.

Mr. Frank Coulson said that the kibble was just balanced by the bow resting on the point of the hook.

Mr. J. B. Atkinson (H.M. Inspector of Mines) mentioned a case at Usworth colliery* where, for additional safety, belts were placed round the shaftmen and attached to the cage-chains by a spring hook, but yet a shaftman who was stated to be attached to the cage-chains fell to the bottom of the shaft.

Mr. Frank Coulson said it occasionally occurred that a spring hook would fail if it got into a certain position in turning round when the load was resting and there was no weight on it; it was then liable to become detached.

DISCUSSION OF PROF. HENRY LOUIS' PAPER "ON A DEFICIENCY IN THE NOMENCLATURE OF MINERAL DEPOSITS."†

Mr. H. W. G. Halbaum (Birtley) said that, in his opinion, the adoption of Prof. Louis' suggestion would rather increase than diminish confusion, since most men used "pitch" and "dip" as interchangeable terms. Mr. A. L. Steavenson's remarks‡ had been described as facetious, but he (Mr. Halbaum) thought that they contained much solid wisdom, and that Mr. Steavenson intended them more seriously than some appeared to suppose.

The use of the word "pitch" appeared to him quite unneces-

* *Reports of Mr. J. B. Atkinson, H.M. Inspector of Mines for the Newcastle District (No. 3), to His Majesty's Secretary of State for the Home Department, under the Coal-mines Regulation Acts, 1887 to 1896, the Metalliferous Mines Regulation Acts, 1872 and 1875, and the Quarries Act, 1894, for the Year 1904*, pages 49 and 50.

† *Trans. Inst. M. E.*, 1907, vol. xxxiv., page 236. ‡ *Ibid.*, page 238.

sary. Prof. Louis had himself admitted in his paper that all the vertical and horizontal angles stood in a simple geometrical relationship to each other. Moreover, it was hardly correct to say that the quantity now sought to be named "pitch" could not otherwise be defined without a "cumbersome circumlocution." It could be simply stated as the dip of a given bearing, and, popularly speaking, that definition was already a part of our mining vocabulary. It would apply to the strike-normal itself, and to every line making an angle with that line in the same plane—the said plane, of course, being that which contained the line of strike and the line of maximum dip.

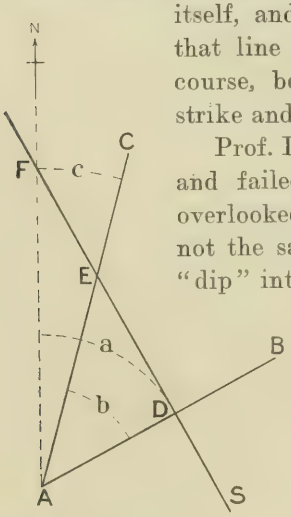


FIG. 3.—PLANE FIGURE CONNECTING HORIZONTAL ANGLES WITH COTANGENTS OF INCLINATION; *a*, *b*, ARE ANGLES OF BEARING (FROM AB); AF, AE, ARE COTANGENTS OF INCLINATION: AD IS THE COTANGENT OF THE FULL DIP.

Prof. Louis spoke of men who had sunk shafts and failed in their objective because they had overlooked the fact that the dip of the strata was not the same in every direction. They took the "dip" into account, but they forgot the "pitch."* But the simple substitution of one word for another would hardly save such men from error. Neither would they be kept right by the trignometrical equation set forth in the paper.

He (Mr. Halbaum) had previously noted that the question of the precise rate at which the dip varied with the horizontal angle seemed to be a little obscure in many quarters. It might therefore be of interest to point out that a very simple plane figure could be constructed, which would answer all the purposes of Prof. Louis' isometrical projection. It proceeded on the same assumption of the dip being regular, and it merely recognized the fact that taking all the lines, normal or oblique, connecting any two parallel lines on the strike of the strata, their relation was such that the dip per unit of length, multiplied by the total length of the line, was a constant quantity. In a plane diagram (fig. 3), therefore, the horizontal angle was shown in plan as usual, whilst the dips were inversely proportional to the lengths of the lines. Thus, let the full dip of the strata be 1 in x, and let it lie

* *Trans. Inst. M. E.*, 1907, vol. xxxiv., page 236.

in the bearing north a degs. east. Then, draw the meridian line AN, and set off the full dip line AB at the angle a with AN. Let it be required to find the dip of the bearing north c degs. east, making an angle b with the strike normal AB. Set off this bearing along AC, as shown in the diagram. Now, the dip of the bearing AB was given as 1 in x, where x was some known numerical value. Let the geometrical equivalent of x be AD, and measure that distance off along AB. Now, through the point D, and at right angles to AB, draw the line of strike SF. It cut AC in E, and also cut AN in F. Then the dip of the bearing AC was one in AE; and, similarly, that of AN was one in AF. For since SF was a level line, it was clear that the total vertical fall from the point A to the line SF would be the same by whatever route they proceeded from the one to the other. And, since, by hypothesis, the dip was regular, the dip on any line parallel to AC would be the same as that on AC itself, and so on, for any other line that might be taken. But if they had to start coining new words and phrases—or, what was worse, officially changing the signification of the old words in current use—merely in order to avoid the imaginary difficulty of having recourse to a simple diagram like that, they would, in his opinion, be lowering their own dignity and status as mining engineers.

Mr. E. R. Field (Victoria, Australia) said that in the Bendigo district of Victoria the word "pitch" was universally used to show the dip of the ore-bodies in the direction of the strike of the lode.

He believed that the usage originated in the Bendigo district, where the celebrated saddle-reefs occur. There, the folded country rock generally has an inclination in the direction of the strike of the strata. In the apex of the anticlines, the large bodies of quartz forming the "caps" of the saddles are found, and, of course, have the same inclination, or pitch, as the strata. The "legs" of the saddles, which are downward continuations of the central quartz-body on either side, have the same strike as the cap, and dip away from it in opposite directions.

Both "dip" and "strike" being thus already employed, a further term was necessary to complete the description of the main ore-body. In other parts of the State, where ordinary fissure-lodes

occur, the term " pitch " was found of great service for referring to the inclination of ore-bodies (shoots) in the direction of the strike of the lode. In a fissure-lode which he had been working recently, the pitch of the shoots was only 4 degrees, the dip of the reef being 65 degrees. It would thus be seen that the pitch was the most important factor in laying out development-work.

Mr. H. W. G. Halbaum said that the pitch of the ore-bed would be the dip of the bearing in that direction.

Prof. H. Louis said that he was obliged to Mr. Field for pointing out that the word was employed in Australia in the same sense as that in which he was trying to define it for use in this country. It was also used in the same signification almost throughout the United States of America, and he had just received a letter from Dr. Raymond (the wellknown Secretary of the American Institute of Mining Engineers) in which he stated that he was bringing forward before that body a short paper on practically the same lines, and was advocating that the word should be restricted to this meaning. The word " pitch " had been used rather loosely in the place of " dip," and his suggestion only meant that for the future they should limit its use to the inclination of ore-shoots or ore-bodies, when such deposits went down actually at angles other than the true dip. He was afraid that Mr. Halbaum had entirely missed the point of his paper; he was not dealing, as Mr. Halbaum seemed to think, with inclinations (other than the dip) within stratified mineral deposits or beds, like the inclination of an oblique roadway in a seam of coal, but with a real natural phenomenon, familiar with those who had to deal with deposits other than beds. Probably Mr. Halbaum's experience of such mineral deposits had been limited, or he would have understood the importance of the point raised. The writer proposed to restrict the term " pitch " to the obliquity of the axes of such ore-deposits as he had referred to. By way of illustrating the importance of precision in the use of these terms, he might point out that Mr. Halbaum had used the word " dip " in a sense that was not strictly correct; by " dip " geologists meant always the inclination at right-angles to the strike, and the word should always be, strictly speaking, used in that sense; for other directions, the word " inclination " should be employed.

DISCUSSION OF MR. WALTER ROWLEY'S "NOTES ON MINING AND ENGINEERING IN AMERICA AND CANADA."*

Mr. Walter Rowley (Leeds) wrote that he had omitted to acknowledge in his paper that the illustrations of the chemical mine fire-engine and of the concrete arching at Burnside colliery† had been reproduced by permission of *Mines and Minerals*, in which paper they had previously appeared.‡

Mr. E. O. Forster Brown (Stoke Bishop, Bristol) wrote that although the number of inspectors in Pennsylvania appeared to be very much greater relatively than in Great Britain, the resulting accidents were altogether out of proportion. That might be partly due to the fact that Pennsylvanian miners were, to a large extent, drawn from a number of different nationalities of probably inferior intelligence to that of the average British miner; but a more forcible reason was that there were fewer precautions taken for securing the safety of the mine. The writer's own experience was that manholes in main haulage-roads were a curiosity, and he had witnessed a set of thirty tubs weighing 5 tons each being run out several hundred yards at a high speed to the mouth of a 4 per cent. grade incline, solely controlled by three trip-riders riding between the tubs.

He (Mr. Brown) agreed with Mr. Rowley that the increased output per miner in the United States of America was due to the thickness of the seams and easy access. With regard to the Connelsville region, however, he would also add that the regularity of the dip of the strata and absence of appreciable faults was a striking feature, and enabled the main haulage-roads to be laid out many years ahead and to the best advantage for dealing with a large output.

With regard to the Niagara Falls, one of the interesting features of the power-houses was the arrangement for dealing with the ice difficulty. The Ontario Power Company had, he thought, adopted plain gratings for the water to filter through. The Electrical Development Power Company, a little farther up the river, had, however, constructed two masonry ice-booms, pierced

* *Trans. Inst. M. E.*, 1907, vol. xxxiv., page 239.

† *Ibid.*, page 242.

‡ *Mines and Minerals*, 1907, vol. xxvii., pages 469 and 542.

by a series of inlet-arches in the outer boom 8 feet and in the inner boom 6 feet below water level, the arches in the inner boom being also provided with gratings.

The five power companies at present in partial operation would, he understood, eventually produce 700,000 horse-power from one-fifth of the 250,000 cubic feet of water per second flowing over the falls. If the total power could be utilized, it would amount to 3,500,000 horsepower, which, on the assumption that a horsepower-hour on the average required 4 pounds of coal, was equivalent to 50,000,000 tons of coal per annum, and could be transformed by a few hundred persons within an area of a few square miles *ad infinitum*.

It was interesting to compare these figures with the statistics of the South Wales coal-field, where, during 1906, 174,660 persons were employed in producing 47,055,969 tons of coal from an area of 1,000 square miles with a limited life. It would seem that an economical method of storing and transporting electricity should go far towards solving the fuel problem of the future.

Mr. Sainte-Claire-Deville's paper on "A Simple Method of Water-stowage employed at No. 5 Pit of the Escarpelle Mines" was read as follows:—

A SIMPLE METHOD OF WATER-STOWAGE EMPLOYED AT NO. 5 PIT OF THE ESCARPELLE MINES.*

By SAINTE-CLAIRE-DEVILLE.†

A simple installation has been laid down at No. 5 pit of the Escarpelle Mining Company, in order to make direct observations on the results that can be obtained by means of water-stowage, having regard to the more or less complete filling of the hollows left by working, to the settlement which the strata undergo, and to the influence of the process upon the maintenance of the roads.

The experiment has been tried in a dip-working upon No. 5 vein at the 1,772 feet (540 metres) level (fig. 1, plate ii.). An incline goes down 164 feet (50 metres), along the slope of the seam, and from it are opened out two cuts (*tailles montantes* = cuts or stopes parallel to the dip), 33 feet (10 metres) wide, starting from two secondary roads at the levels of 82 and 164 feet (25 and 50 metres) respectively. At the time when water-stowage was commenced (January, 1905), 131 feet (40 metres) of coal had been removed from the first cut, and 65½ feet (20 metres) from the second, by this method of stoping, and the places stowed in the ordinary way with dirt obtained from working the seam, and with dirt brought in from other parts of the pit, and tipped at the top of the cuts. Seam No. 5 has in this place a thickness of from 60 to 67 inches (1·5 to 1·7 metres); it consists of two beds of coal, each 15¾ inches (0·4 metre) thick, one next to the roof and the other next to the floor; the parting between them consists of black and grey shales, 27½ to 35½ inches (0·7 to 0·9 metre) thick; the mean angle of inclination of the seam is 35½°.

The roof was rather bad in the stopes, especially in the neighbourhood of the upper road of the first cut, which was a pony-

* "Procédé simplifié de Remblayage hydraulique employé à la Fosse No. 5 des Mines de l'Escarpelle," by Mr. Sainte-Claire-Deville, *Comptes-rendus mensuels des Réunions de la Société de l'Industrie Minérale*, 1906, pages 31 to 37.

† Translated by Prof. Henry Louis, M.A.

way, above which the coal had been removed during the years 1901-1904. The maintenance of the inclined roads from the stopes was always rather costly.

The water-stowage was arranged in the two cuts on the return side without stopping regular work for a moment. They were simply transformed into stopes worked upwards off an inter-level road (*tailles chassantes*) 82 feet (25 metres) in width. The coal when cut slips down from stope to stope to the foot. As regards the dirt, the workmen throw it behind them without packing it against the roof.

The first cut employs five men, the second six, the two together getting from 65 to 75 tubs of coal per day. The first cut is stowed directly from the top; the second is supplied by a short row of pipes, which take the stowage from the pony-road (fig. 4, plate ii.).

Stowage.—The material employed for stowing consists of shales from the washery for the first cut, and ashes from the boilers, screened through round holes 0·79 inch (20 millimetres) in diameter, for the second. They are sent down in tubs by the shaft, at the end of the shift after the miners have ridden to bank. These tubs are coupled up to the empty trains, and thus carried, without additional cost, to the double roadway close to the incline, so that they are in readiness for the stonemen's shift at 5 p.m. Each cut is supplied by a hopper of small dimensions, 37½ inches (0·95 metre) high, 40 by 35½ inches (1 by 0·90 metre), or 31 cubic feet capacity, equal to the contents of a tub (fig. 4, plate ii.). They are made of planks 0·787 inch (2 centimetres) thick and lined with thin sheet-iron; they are set up on the floor of the seam, and are kept in place by means of chains. Their upper edge is a little below the surface of the pony-road. The tubs are emptied into them by being thrown over on to their sides.

Movable Hopper (figs. 2 and 3, plate ii.).—For the first cut, the hopper is moved in proportion as the work advances, every 14¾ feet (4·50 metres).

The mixing-water comes from a system of pipes, and is introduced in part into the interior of the hopper by a pipe 0·79 inch (20 millimetres) in diameter, the jet of which washes out the material for stowage through a sliding door placed in the

base of the hopper; the other part flows in at the apex of the hopper, beneath the sliding door, through a horizontal pipe 2 inches (50 millimetres) in diameter, perforated with twenty holes 0·39 inch (10 millimetres) each in diameter, the jets from which carry the material into a series of troughs made of wood lined with sheet-iron, suspended from the mine-timbers and descending into the cut within about 6½ feet (2 metres) of the level of the stowage.

Fixed Hopper.—An identical hopper supplies the second cut. It is stationary, at the head of a passage left in the old dry stowage of the first cut. The water is introduced in the same way, but the supply-pipe has twenty-five holes of 0·47 inch (12 millimetres) diameter, in order to get a bigger water-supply. The apex of the hopper enters a sheet-iron funnel covered by a screen with round holes 2 inches (50 millimetres) in diameter, and attached to a column of pipes of 4·33 inches (110 millimetres) in internal diameter, running along the passage for a length of 82 feet (25 metres), and then by an elbow of 40 inches (1 metre) radius, into the upper road of the second cut, so as finally to pour the stowage into the troughs of this cut. In order to avoid too great a length of pipes, the second hopper will be removed to a new passageway 213¼ feet (65 metres) from the previous one, from which it can supply the stowage for a length of some 230 feet (70 metres), that is, 115 feet (35 metres) on either side.

Obstructions in the Pipes.—Some experiments have been needed, in order to avoid the formation of obstructions in the pipe-line. It has been found necessary to avoid the shales, which were found to be too heavy. Screened boiler-ashes, sometimes mixed with dirt (fragments of bricks, old cinders, or small shale), have given good results. Placing a pipe so as to inject water at the lower elbow in the direction of the flow has also had a good effect.

Water-supply.—The water-supply is taken from a little reservoir 883 cubic feet (25 cubic metres) in capacity, excavated at an incline close to this seam, from which the water is pumped into the pipe-system. The water which has been used carries very little slime with it. It runs down to the bottom of the incline, whence a pump forces it up to the reservoir. The only settling-pit is a sump of 10 feet (3 metres) cube in capacity, from which this force-pump draws; it is cleaned out at long intervals.

Work at the Face (fig. 4, plate ii.).—The stowage is done in each cut upon four cuts (*travées*), or a length of $14\frac{3}{4}$ feet (4·50 metres). The stowage is kept in place at the bottom of the face by a block measuring $6\frac{1}{2}$ (2 metres) by $8\frac{1}{4}$ feet (2·50 metres), of dry stowage, kept in place by timbers. At one side of it a barrier is made up of brattice-cloth strengthened by sheets and planks attached to the timbers. Experience has shown that with the comparatively steep slope of cuts at these mines one should attempt to get a filtering surface sufficiently great to prevent any serious accumulation of water at the surface of the stowage, in order to avoid dangerous overloads capable of breaking through the pillar; the planks must therefore not be put too close together. The barrier is taken down after each series of four cuts has been stowed, in order to be used for the next series. One can then see that the stowage stands perfectly in a vertical wall, and sets quite close against the roof.

Consumption of Water.—The consumption of water, ascertained by a counter placed upon the feed-pump, shows very accurately 1 cubic foot of water per cubic foot of stowage for the shales of the first cut, and 1·65 cubic feet per cubic foot of the boiler-ashes for the second cut. The figure for the first cut may appear somewhat high, seeing that the material is transported in open troughs at an inclination of 35°; in fact, in this case the proportion of water is determined only by the degree of fluidity necessary to cause the material to flow freely into all the angles of the cut and the irregularities of the roof. The stowage runs very differently in the two places.

In the first cut, a cone of shales forms at the commencement of the operation, below the last trough. The apex of this cone is cut down by the somewhat violent jet of water flowing continually upon it; gutters are excavated upon the angles, and little torrents run through these, carrying the material of the stowage to right and left. Thus the condition necessary and sufficient for the stowage to be forced thoroughly against the roof is that the mean angle of the sides of the cone shall be less than the slope of the seam. In practice, angles of from 12 to 15° have been observed.

It is, moreover, necessary that the mixtures should be quite homogeneous. If the proportion of stowage is abruptly in-

creased, there is a great risk of leaving hollows. This observation, suggested by experience, justifies the employment of hoppers with gates enabling the flow of shales to be regulated accurately. When the mixture has to be conveyed in pipes, the part played by the water as a transporting medium becomes predominant, and the proportion of water necessary to avoid obstructions is greater than that required to deposit the material. The stowage is then deposited in practically horizontal layers.

Rate of Work and Cost.—The material is, on the average, tipped at the rate of 40 tubs per hour. Two active trammers and an assistant can even work at the rate of a tub per minute, but cannot keep up this pace for any length of time. As a means of comparison, an ordinary trammer took 2½ days to tip and stow 25 tubs of ordinary stowage in the first cut. Hydraulic stowing is carried on by sets of 50 tubs at the first cut, and 30 to 35 at the second. The mining company have not a reserve of water sufficiently great to enable them to do more, and this, moreover, suffices for the need of their workings.

The following is the cost of the stowage calculated in the same way as has been done by Mr. Lafitte for the Lens Collieries, and only taking into account the expenses incidental to this particular process :—

Description.		Labour at the surface.	Labour, tipping underground.	Barriers.	Materials for the barriers.	Total.
		Francs.	Francs.	Francs.	Francs.	Francs.
1st cut	Per cubic metre of stowage	0·141	0·106	0·101	0·050	0·398
	Per ton of coal extracted	0·087	0·065	0·062	0·020	0·234
2nd cut	Per cubic metre of stowage	0·249	0·109	0·095	0·050	0·503
	Per ton of coal extracted	0·163	0·071	0·062	0·020	0·316

N.B.—1 cubic metre is equal to 35·316 cubic feet; 1 franc is equal to 9½d.

Screening the boiler-ashes increases the working-cost for the second cut, without, however, making it prohibitive. The outlay for compressed air is not included, because the steam required is supplied to the compressor by a battery of boilers heated by the waste heat of coke-ovens. It should be added that the maintenance of the tramlines has been diminished by two-thirds, and that the roof of the workings has become much better, so that the cost of hewing has been diminished. The output per man has been increased by about 4 cwts. (200 kilo-

grammes) for each incline. The ridding-out of the pony-road has also been saved, as this road would have been very much broken down in making the first cut by the ordinary method.

Settlement of the Stowage.—Direct observations upon the settlement of the stowage have been recently made in cutting a passage through the first cut, through the stowage, which was then nearly six months old. The thickness of the same had decreased only from 6 to 10 per cent. in different places; the roof has remained perfectly firm, and does not show the slightest break. The shales are admirably packed against it, and form a very compact mass. The dirt from the seam which remained upon the floor is also well packed down. A simple calculation has, moreover, shown that its settlement had been reduced to one-tenth by the flow of water which had passed over them.

There is every reason to suppose that the settlement will be still less in working the second cut, which is operating in a district further removed from the zone of fracture created by the previous workings.

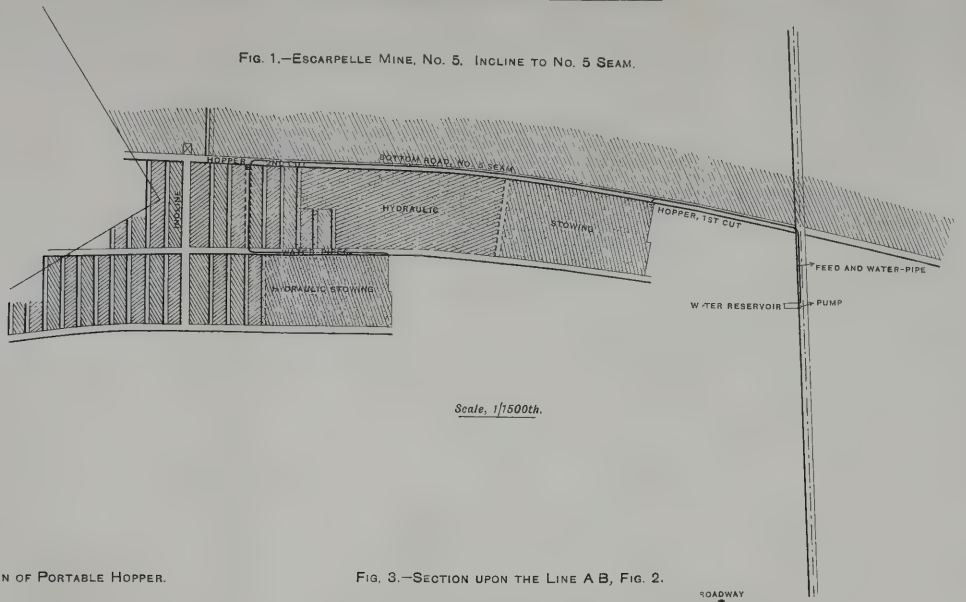
The Application of this Method to any District.—The principle of doing away with pipes can be applied with advantage in thin seams, and will be compulsory whenever a supply of material and water in the upper levels (as in the case of a number of the workings at these mines) is not available. The entire plant required comprises a pump distributing water to the roads, a hoist driven by compressed air to elevate the material for stowing, and one portable hopper for each working. In order to be able to stow roads as well as the workings, and to have a sufficiently rapid production, the best method of working will be by long pillars. It is evident that if it were necessary to adopt water-stowage throughout the whole of a mine, and to deposit 35,316 or even only 17,658 cubic feet (1,000 or 500 cubic metres) of stowage, this simple method would have to give place to installations adapted for a more vigorous output both underground and at the surface. It might even be almost inapplicable on a large scale, on account of the disturbance to the normal working caused by riding down and transporting any considerable tonnage of stowage, as also by the quantity of compressed air consumed. The cost price is low in No. 5 seam, because the mining company take advantage of any unoccupied time of the hangers-

The Institution of Mining Engineers
Transactions, Vol. XXXIII.

To illustrate Mr. Sainte-Claire-Deville's Paper on "A Simple Method of Water-stowage Employed at No. 5 Pit of the Escarpelle Mines."

Vol. XXXI. Plate II.

Fig. 1.—Escarpelle Mine, No. 5. Incline to No. 5 Seam.



Scale, 1/1500th.

Fig. 2.—Plan of Portable Hopper.

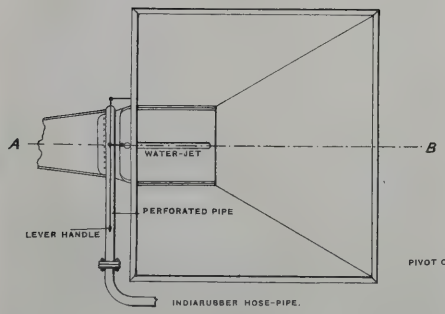
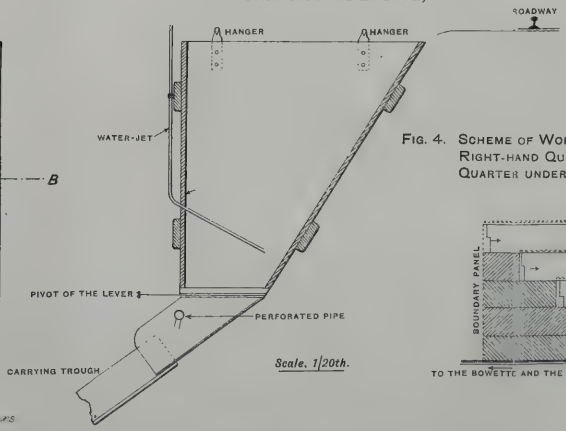
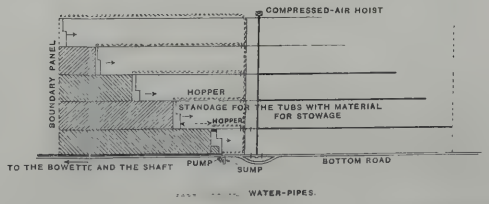


Fig. 3.—Section upon the Line A B, Fig. 2.



Scale, 1/20th.

Fig. 4. Scheme of Working by Cuts and Packing of Roads; Half the First Right-hand Quarter being Opened Out: Half the First Left-hand Quarter under Extraction.



The North of England Institute of Mining & Mechanical Engineers
Transactions, 1907-1908.

Vol. LVIII., Plate II.

J. & T. Bell & Co., Ltd., Newcastle upon Tyne

on, putters, and drivers; and it is only within the limits thus admissible that this simple process is economically applicable. With these reservations, it is thought that pits wishing to practise water-stowage in only a small area of their workings can with advantage utilize the methods just described.

Mr. Sainte-Claire-Deville (Herserange, France) wrote that it might be of interest to the members of the Institute to know that, in consequence of the first experiments noted in his paper, water-stowage had been applied in other districts of the same pit; more particularly, the method of working indicated in the last paragraph of his paper had been employed. Although No. 9 seam, which was being worked, was only about 20 inches ($\frac{1}{2}$ metre) in thickness, there had been no increase in working-costs, because the great firmness resulting from water-stowage had allowed of extremely long cuts being made, and, in consequence, considerable expense in cutting and maintaining roadways had been saved.

Personal experience of water-stowage, extending over a period of $2\frac{1}{2}$ years, had brought the writer to the conviction that it very much improved the conditions of the roof of the seams. A roof which might be bad with ordinary working, became good when water-stowage was employed. It also diminished greatly the risk of accidents through falls of stone, and, as a matter of fact, in the eight or ten workings which had been exploited by the new process from January, 1905, to August, 1907, at the No. 5 pit of the Escarpelle mines, no accident of this kind, severe or slight, had occurred. The advantage mentioned might, perhaps, be less marked in English seams, which were renowned for the great strength of their roofs.

A vote of thanks was accorded to the author for his interesting paper.

Mr. H. W. G. Halbaum read a paper upon "Mine-Ventilation: The Symmetric Relationship of Pressure, Velocity, and Conductive Area."

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
APRIL 11TH, 1908.

MR. JOHN H. MERIVALE, PRESIDENT, IN THE CHAIR.

The ACTING SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on March 28th and that day.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. JOHN NORTON GRIFFITHS, Consulting Engineer, 62, London Wall, London, E.C.

Mr. WILLIAM HERDMAN, Manager of Metalliferous Mines, Hilton, Appleby.

Mr. SHONOSUKE HOSO, Mining Engineer and Colliery Manager, Miike Colliery, Kyūshū, Japan.

Mr. ERNEST HUMBLE, Colliery Manager, Lawson Street, Hamilton, Newcastle, New South Wales, Australia.

Mr. JAMES WILLIAMS, Mining and Mechanical Engineer, c/o Messrs. James Pollock, Sons, and Company, Limited, 3, Lloyd's Avenue, London, E.C.

STUDENTS—

Mr. ERIC LOUFWIN FORD, Mining Student, Armstrong College, Newcastle-upon-Tyne.

Mr. NORMAN LESLIE PREST, Mining Student, Hardwick Hall, Castle Eden, S.O., County Durham.

Mr. PHILIP WRIGHTSON, Mining Student, 5, Westbourne Grove, Hexham.

DISCUSSION OF MR. H. W. G. HALBAUM'S PAPER ON "CAST-IRON TUBBING: WHAT IS ITS RATIONAL FORMULA?"* AND OF DR. JOHN MORROW'S PAPER ON "THE STRENGTH OF CAST-IRON TUBBING FOR DEEP SHAFTS."†

Mr. H. W. G. Halbaum (Horden) wrote that he regretted that temporary pressure of work prevented his dealing fully at that moment with Dr. Morrow's reply, but he would assuredly do so at no very distant date. In the meantime, he would direct particular attention to the significant fact that, in the reply referred to,‡ Dr. Morrow had practically withdrawn his "plate-formula," just as Prof. Galloway had already repudiated the French formula saddled upon him by Prof. Louis, and just as Prof. Louis himself had quietly thrown aside the formula for p, given by him (Prof. Louis) in *Practical Coal-mining*.§

Those early tangible results of his (Mr. Halbaum's) criticisms effectively disposed of Prof. Louis' assertion that there had been no need for him (Mr. Halbaum) to trouble about "the simple case of the plain cylinder." It would be subsequently shown that almost the whole of the remaining positions held by Prof. Louis and Dr. Morrow were equally untenable.

As for Prof. Galloway's rejoinder,‖ he (Mr. Halbaum) had much pleasure in accepting that gentleman's explanations. He would merely point out with regard to paragraph (3)¶ that, by Prof. Louis' account, R was fixed by the formula as one-third of the ultimate stress, whereas Prof. Galloway implied that the engineer might take it at one-tenth if he thought fit. Was not that amending the formula further? With reference to paragraph (7), that gentleman's formula, as defined by himself, was simply the "thin"-cylinder formula for external pressures, stated in terms of the inside radius. His (Mr. Halbaum's) rational formula, on the other hand, was rational for the tubbing case, simply because it gave the thicknesses equal to those, or slightly more than equal to those, which would be obtained by the strictly rational thick-cylinder formula independently

* *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 567.

† *Ibid.*, 1907, vol. xxxiv., page 100. ‡ *Ibid.*, 1908, vol. xxxv., page 70.

§ 1907, divisional-volume i., page 137.

‖ *Trans. Inst. M. E.*, 1908, vol. xxxv., page 51.

¶ *Ibid.*, page 52.

deduced in the third appendix of his (Mr. Halbaum's) paper.* If Prof. Galloway still thought the two rules similar, he (Mr. Halbaum) would suggest that he should test them by finding the thicknesses given by each when, say, $\frac{f}{p}=4$.

DISCUSSION OF MESSRS. J. W. FRYAR AND ROBERT CLIVE'S PAPER ON "THE SINKING OF BENTLEY COLLIERY."†

Mr. Frank Coulson (Durham) asked whether the tubbing put in at Bentley colliery was faced and bolted together with drilled holes and properly turned bolts countersunk with lead and steel weazes, in a similar manner to that adopted by German mining engineers. It seemed to him that on one or two occasions the piles were driven too far in advance of the guard-ring at the bottom, and the piles were, in consequence, bent in. He would like to know whether it would not have been an advantage to drive the piles a shorter distance ahead. In the case of wooden piles, the practice was to drive them in a little distance and then clear the way for each pile, and also prevent, as far as possible, sand getting in. At Bentley colliery there appeared to be more sand drawn from the pit than was necessary. He had had the privilege of seeing the system of piling adopted there, and he thought it by far superior to any other that he had seen. If there was any mistake, it was in driving the piles too far in front of the bottom of the tubbing. He would also like to ask whether the wooden sheeting which was put in kept the water from coming through the bolt-holes, as it seemed rather a crude method to put in with tubbing bolted together. He would have imagined that tubbing properly faced and put together with leaden wire, or even with nothing at all (as was the case at many of the French collieries), just wedging the front with soft-iron wedges, would have been better than putting in the sheeting. The old idea was always to keep as much weight off the top of the pit as possible in sinking through quicksand. At Bentley there seemed to be a large amount of weight in the shape of a concrete block, which he supposed was for the sake of having something to shove against

* *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 607.

† *Ibid.*, vol. xxxiv., page 389.

in forcing the piles down. If the weight had been kept clear away from the pit, there would not have been the same amount of sand to draw out. In the case of sinking the second pit, he took it that the whole of the water would be drained out of the sand, and it would be a comparatively easy operation.

Prof. Henry Louis (Newcastle-upon-Tyne), referring to the Flottmann drill, asked what were its dimensions, and how it was supported: was it a hand-held drill, or was it supported on a tripod or bar?

Mr. J. W. Fryar (Bentley) agreed that in the sinking of the first pit the piles were put too far in front of the floating-ring, but it must be borne in mind that they had to obtain their experience at this pit. In the second pit, and in the later part of the first pit, the piles were pushed not an inch further out than was necessary to keep the bottom of the pit quiet. Indeed, they were obliged to put them further out in the case of the first pit, because of the boiling up of the water from the stonehead, which was much more violent than in the second pit, where it had not nearly so much force. The pit was wet all the time that they were sinking, and in a great many places the sand, which was of the consistency of mud, had to be filled into buckets.

With regard to the tubbing, as stated in the paper, the outer tubbing was 23 inches in diameter, and there was also an inner tubbing; the outer tubbing, which was put in following the piles, was simply bolted together, with wooden sheeting in between. The water always came in at the bottom, and when they got down it came in all round about the piles, partly from the sheeting where it was jointed, and through the bolt-holes; but they experienced no great difficulty with that, because as soon as they got to the crib-bed the permanent tubbing was put inside and sealed off in the ordinary way, filling up between the two tubbings. They had to go more upon the strength than anything else. It was satisfactory to know that they had last Saturday got down to the coal and obtained a good seam, about 9 feet 3 inches thick, which would amply repay the expense and trouble involved in the initial difficulties of dealing with the quicksand.

The Flottmann drill was a very small drill, not much larger than the ordinary Boyer hammer. It was only about 1 foot 9

inches or 2 feet in length, and 3 or 3½ inches in diameter. It was certainly the best mining drill for sinking pits that he had come across, as in working it was only necessary to couple a flexible pipe on to it. They carried these flexible pipes down the sides of the shaft, with absolutely no machinery in the pit-bottom; a man simply coupled it on and held the drill in one hand, and it would go steadily down—indeed, after about 12 or 18 inches it would even go by itself. After the sumper-holes were drilled, a man could get round the side and have all the side-holes drilled during the time that the sumper-hole was cleared.

In reply to questions by Prof. Louis and Mr. W. C. Blackett, Mr. Fryar further said that the depth of the hole drilled was about 7 feet; and that the drill would go best in hard stone; it did not go at all well in soft shale or fire-clay, but it went very well indeed in limestone.

Mr. Coulson asked whether these drills would work equally well in damp ground. He should imagine that they would work better in very wet or very dry ground, than in ground which contained a little moisture.

Mr. Fryar said that in using the drill they generally kept the hole filled with water.

Mr. H. F. Bulman's "Memoir of Martin Walton Brown" was read as follows:—

MEMOIR OF MARTIN WALTON BROWN.

By H. F. BULMAN.

Martin Walton Brown was born in Newcastle-upon-Tyne on June 12th, 1854. He was the only child of William Brown, a flour-merchant, and the last tenant of the old mill in Jesmond Dene.

Walton Brown commenced his education in his native city, at the celebrated Percy Street Academy of the late Rev. Dr. J. Collingwood Bruce, where many wellknown north-countrymen were educated, and was afterwards at Dr. Dyson's school at Bradford, Yorkshire. In 1871, he obtained by examination one of four open exhibitions at the Newcastle College of Physical Science (now Armstrong College), of which he was one of the original students, the College having just been founded in that year. He attended the lectures during the session 1871-1872, and obtained a prize in geology. His attendance was co-temporary with the first year of his apprenticeship as a mining student, which he served with the late Mr. S. C. Crone at the Killingworth and other Northumberland collieries belonging to Messrs. John Bowes and Partners, Limited. The period of his apprenticeship (1871-1874) was one of unprecedented prosperity in the British coal-trade, and considerable developments, including three new sinking-shafts, were proceeding at the collieries under Mr. Crone's charge. Altogether, there was ample opportunity for a keen student, like young Walton Brown, to gain a wide experience in practical colliery work.

In those early days, at the age of 20, he showed his natural bent towards literary work, and was already writing articles for the mining journals. He was especially interested in mine ventilation, a subject on which, in later years, he was a recognized authority. It was probably his uncle, the late Mr. J. J. Atkinson (H.M. Inspector of Mines), who directed his attention to this subject, as Mr. Atkinson was the first in England to set out clearly the laws that govern mine-ventilation.

Walton Brown had also grasped the fact that much valuable information may be obtained from foreign sources. He had learnt French, and used to study the *Annales des Mines* and the publications of the Société de l'Industrie Minérale. Later on, he learned German, and thus kept himself informed of Continental progress in mining.

After completing his four years' apprenticeship at Killingworth, he went to Hamsteels colliery, near Durham, as assistant to the late Mr. R. S. Johnson, the managing owner, and whilst there, in 1876, he passed the examination for and obtained a first-class colliery manager's certificate. He spent three years at Hamsteels, leaving to take up a position as assistant to the late Mr. E. F. Boyd, of Moor House, Leamside, County Durham.

Mr. Boyd was the mining agent for the Ecclesiastical Commissioners (Durham Chapter Estates), and for many other coal-lessors, and the work of his assistants consisted largely in visiting collieries all over the county to obtain the account of coal worked, and to put up tracings of the working-plans. It was Mr. Boyd's rule that whenever an account was got, a visit should be paid underground to inspect the workings and take sections of the seam. His assistants, therefore, besides gaining an insight into tentale accounts and coal-leases, saw a good deal of colliery work.

Mr. Boyd had a high opinion of Walton Brown's capabilities, and it was owing, no doubt, to his recommendation, and to that of Mr. R. S. Johnson, that in 1880 he obtained the appointment, under the late Mr. T. W. Bunning, of Owners' Secretary of the Joint Committees of the Coal-owners' and Workmen's Associations for the counties of Northumberland and Durham. Mr. Bunning held also the appointments of Secretary to The North of England Institute of Mining and Mechanical Engineers, and to the United Coal Trade Association of Northumberland and Durham. On Mr. Bunning's resignation, in 1888, these appointments were divided, and Walton Brown remained as Secretary to the Joint Committees, a position which he retained until his death 19 years later.

In the discussion of the many and varied questions relating to wages and customs which were brought before the Joint Committees, with their independent Chairmen, he was pitted against the able Secretaries of the Miners' Unions of the two northern counties. His strong points were his accurate memory of pre-

vious cases and decisions, and the ready way in which he could bring forward information required for the guidance of the Committees.

His association with The North of England Institute of Mining and Mechanical Engineers began in 1871, when he joined it as a student. He was, in 1887, elected a member of the Council, and, in 1891, on the retirement of Prof. G. A. L. Lebour, was appointed Secretary. In the same year, he was also appointed Secretary to The Institution of Mining Engineers. The federation of the Mining Institutes dates from 1889, but Volume I. of the *Transactions* for the year 1889-1890 was not published until 1892, and bears his name as Secretary and Editor. The success of the Institution has been largely due to the work, the care, and the attention which he ungrudgingly gave to its affairs. The admirable character of the *Transactions*, and his merits as Editor, were recognized by the International Jury of Awards of the Louisiana Purchase Exposition, 1904, when they awarded a gold medal to the Institution and a silver medal to Walton Brown.

He made his first contribution to the *Transactions* of The North of England Institute of Mining and Mechanical Engineers in 1882 with a translation from the *Annales des Mines* of "Remarks by Mr. E. Mallard on Mr. Lindsay Wood's 'Experiments showing the Pressure of Gas in the Solid Coal.'"

In 1884, he brought before the Institute the question of the possible connection between earth-tremors and the issue of gas in mines; and a committee was subsequently appointed to investigate the matter, a seismograph and other apparatus being established at Marsden colliery in the autumn of 1886, by the permission of the late Mr. John Daglish. Walton Brown took a leading part in the investigations, and the report of the Committee was published in 1887.

He acted as Secretary to the Committee appointed to enquire into the explosion of an air-receiver at Ryhope colliery, and he drew up the report published in 1888. He contributed a valuable paper on the Correlation of the Coal-seams of the Carboniferous Formation of the North of England—a paper which must have entailed much study and investigation. In it he advanced a quite original theory of the formation of the coal-seams, which he states as follows:—"From a full consideration of the relative

positions of the coal-seams in the true measures, it appears possible that they should be considered as portions of one and the same seam which was in continuous formation during a long period of time. If this theory be based upon fact, the Coal-measures must be then considered as one seam of coal, with intercalated bands or beds of sandstone, shale, and other rocks."*

He was an active member of the Flameless Explosives Committee appointed on March 31st, 1888; and during 1890, in conjunction with the late Mr. W. J. Bird, he translated the valuable and lengthy *Report of the (French) Commission on the Use of Explosives in the Presence of Fire-damp in Mines.*

In 1888, The North of England Institute of Mining and Mechanical Engineers, in conjunction with the Midland Institute of Mining, Civil and Mechanical Engineers and the South Wales Institute of Engineers, appointed a Committee to conduct experiments and report on mechanical ventilators. Walton Brown took a very active part in the work of this Committee, and drew up the valuable and exhaustive report printed by The Institution of Mining Engineers in 1899.† Few men knew more about fans and mine-ventilation than he did, and many of the papers which he contributed to the *Transactions* and to other publications deal with this subject.

A complete list of the papers contributed by Walton Brown to the *Transactions* of The North of England Institute of Mining and Mechanical Engineers and of The Institution of Mining Engineers is as follows:—

"Translation of Remarks on Mr. Lindsay Wood's 'Experiments showing the Pressure of Gas in the Solid Coal,' by Mr. E. Mallard," *Trans. N. E. Inst.*, 1882, vol. xxxii., page 123.

"On the Observation of Earth-shakes or Tremors, in order to Foretell the Issue of Sudden Outbursts of Fire-damp," *ibid.*, 1884, vol. xxxiii., page 179.

"On the Marsaut Lamp," *ibid.*, 1885, vol. xxxiv., page 161.

"Translation of New Mining Regulations of Belgium," *ibid.*, 1885, vol. xxxiv., page 265.

"Experiments on Wolf Safety-lamp," *ibid.*, 1885, vol. xxxiv., page 293.

"Translation of Regulations for the Management of Fiery Mines in Prussia," *ibid.*, 1886, vol. xxxv., page 167.

"An Account of Experiments in France upon the possible Connection between Movements of the Earth's Crust and the Issues of Gases in Mines," *ibid.*, 1886, vol. xxxvi., page 43.

* *Trans. N. E. Inst.*, 1887, vol. xxxvii., page 15.

† *Trans. Inst. M. E.*, 1899, vol. xvii., page 482.

"On a Form of Apparatus for the Rapid Determination of Specific Gravities of Bodies," *Trans. N. E. Inst.*, 1887, vol. xxxvi., page 95.

"A Further Attempt for the Correlation of the Coal-seams of the Carboniferous Formation of the North of England, with some Notes upon the Probable Duration of the Coal-field," *ibid.*, 1887, vol. xxxvii., page 3.

"Report of the Committee appointed to inquire into the Observations of Earth-tremors, with the view of Determining their Connection (if any) with the issue of Gas in Mines," *ibid.*, 1887, vol. xxxvii., page 55.

"Mechanical Ventilators: Observations to be made and Instructions to the Engineers," *ibid.*, 1888, vol. xxxvii., page 189.

"Report of the Committee Appointed to enquire into the Explosion of an Air-receiver at Ryhope Colliery," *ibid.*, 1888, vol. xxxvii., page 197.

"The Pieler Spirit-lamp as a Fire-damp Indicator," *ibid.*, 1889, vol. xxxviii., page 177.

"Experiments with Explosives used in Mines," *Trans. Inst. M. E.*, 1890, vol. ii., page 49.

"Experiments with Carbonite" (in conjunction with the late William Foggin), *ibid.*, 1890, vol. ii. page 85.

"The Waddle Patent (1890) Fan," *ibid.*, 1891, vol. ii., page 173.

"The Lee Alarm Water-gauge," *ibid.*, 1891, vol. iii., page 128.

"The Roberts Shot-firing Lamp," *ibid.*, 1891, vol. iii., page 129.

"The Rateau Ventilator," *ibid.*, 1892, vol. iii., page 410.

"The König Differential Water-gauge," *ibid.*, 1892, vol. iii., page 452.

"The Veitch-Wilson Improved Lamp-pricker," *ibid.*, 1893, vol. vi., page 448.

"The Equipment of Exploring Expeditions," *ibid.*, 1898, vol. xv., page 443.

"Mechanical Ventilators: Report of the Committee of The North of England Institute of Mining and Mechanical Engineers, and the Midland Institute of Mining, Civil and Mechanical Engineers," *ibid.*, 1899, vol. xvii., page 482.

"Newcomen Engines," *ibid.*, 1901, vol. xxii., page 653.

"Memoir of the late John Daglish," *ibid.*, 1907, vol. xxxiii., page 201.

In addition to the above, he also prepared the "Barometer, Thermometer, Etc., Readings" for the years 1888 to 1905 inclusive.

In 1890, he became Secretary to the Board for Examinations for the Newcastle-upon-Tyne Mining District. He maintained his connection with Armstrong College in later years, when he was resident in Newcastle-upon-Tyne, and in 1898 was one of the founders of the Old Students' Union, acting as Treasurer until his death. He was President of the Union during the years 1898, 1899, and 1900, and again in 1907. He sometimes gave the lectures on mining at the College in the absence of the Professor of Mining.

Owing to the position which he held in the mining world, and to his wide acquaintance with all sorts of mining people,

he was frequently applied to in connection with mining appointments, especially abroad. Many men in various parts of the world owe their positions to his recommendation and advice, given freely and gratuitously. He was singularly free from mercenary motives.

His office in Newcastle-upon-Tyne was invaded by numerous visitors, to such an extent as sometimes to interfere seriously with his duties; and, in consequence, much of his work was done at home in the evenings, where he was free from interruptions. His stores of information on mining matters were always at the service of his friends, and his readiness to help others sprang from real kindliness and human sympathy.

He was essentially a robust individuality, with a large share of the sturdy independence, the dogged persistence, and the hard-headedness, which are prominent characteristics of many Northumbrians. He had his own way of doing things, from which he was not easily moved.

A comical instance of his original turn of mind may be mentioned. On one occasion, in his student days, he actually had a photograph taken of the back of his head—what he called a "back elevation"—as he did not see why photographs should be confined to "front views."

His manner did not always convey a right impression of his real nature; and the high compliment may be paid him that he was most liked and appreciated by those who knew him best.

He was an instance of a man who, without influential friends, and lacking rather those natural gifts of manner and address which are outwardly attractive, made his way to a good position on the strength of his own solid merits, and in that position did most useful service to the industry and science of mining.

The value of the Mining Institutes in stimulating their members, in spreading useful knowledge and in promoting the safe and efficient working of mines, is nowadays taken rather as a matter of course:

"What we have, we prize not at its worth."

In that valuable work, during the last seventeen years, Walton Brown took a leading part.

During his secretaryship, The North of England Institute of Mining and Mechanical Engineers nearly doubled its member-

ship and income; for in 1891, the membership was 670 and the income £1,590, whilst in 1907, the number of members was 1,307 and the income £2,928.

The thirty-three volumes of the *Transactions* issued during his secretaryship of The Institution of Mining Engineers, and edited by him, are a lasting monument to his memory.

In 1885, he married Isabella, daughter of the late John Chrystal, of Lumley, County Durham, who survives him together with a son and daughter. He died suddenly at his residence, in Newcastle-upon-Tyne, on November 22nd, 1907, in his 54th year, and was buried at Jesmond Old Cemetery, Newcastle-upon-Tyne. The large number of people present at the funeral, including representatives of most of the important mining institutes and associations of the United Kingdom, testified to the esteem in which he was held and to the regret felt at the loss which the mining world had sustained.

On the motion of Mr. W. C. Blackett, seconded by Mr. T. E. Forster, a vote of thanks was accorded to Mr. Bulman for his memoir.

Mr. Lawrence Austin's description of the "Demonstration of Rescue-apparatus, Felling, August 31st, 1907," was read as follows:—

DEMONSTRATION OF RESCUE-APPARATUS, FELLING, AUGUST 31st, 1907.

Compiled by LAWRENCE AUSTIN.

An experimental gallery (figs. 1 and 2, plate vii.), 170 feet long, had been erected by Mr. C. B. Palmer, the conditions resembling, as nearly as possible, those that might be met with in a thin coal-seam after an explosion. One side of the gallery was of wire-netting, so that the movements of the wearers of the various apparatus were in full view of those witnessing the demonstration. It was so arranged that narrow and obstructed roadways had to be contended with, piles of débris surmounted, passages cleared through falls of stone, and other obstacles negotiated. A chamber, to be filled with both carbonic acid and sulphur-dioxide fumes, had also been constructed, into which the wearers of the apparatus were to enter.

A programme of the various tests to which each apparatus would be submitted had been drawn up, as follows:—

Each apparatus to be explained, five minutes being allowed for such explanation.

The weight of each apparatus and of the wearer to be recorded, and the men examined by doctors.

Each competitor to walk 100 yards, climb a ladder twice, and then enter the mine; a member of the committee accompanying him, outside, as an observer.

After leaving the first portion of the mine, the competitor to walk along a plank and enter the return-airway, where he must set two props and 4 yards of brattice-cloth.

The competitors must then enter the chamber filled with carbonic acid, remaining therein ten minutes, during which time they must each saw two pit-props.

On leaving the chamber, the first portion of the mine, the intake-airway, must be re-entered, and a dummy figure, which will be replaced for each competitor, brought out.

A 56-pound weight must then be raised 8 feet high twenty times by each competitor.

Each competitor having completed the foregoing tests, measurements will be taken of the smallest opening through which each wearer and apparatus can pass.

Finally, each apparatus to be re-charged, one assistant being allowed to each competitor, the time of re-charging being recorded, after which the competitors must re-enter the chamber, now filled with sulphur-dioxide fumes.

Five makes of apparatus, namely, the Aerolith, Dræger (helmet and mouthpiece types), Fleuss-Siebe-Gorman, Weg, and Westphalia (helmet and mouthpiece types), took part in the demonstration, a short description of each being as follows:—

Aerolith.—The Aerolith apparatus (figs. 3, 4, and 5, plate viii.) utilizes the principle of liquid air evaporating into about 800 times its own volume of breathable air, and has already been described at length in a paper read by Mr. Otto Simonis to the members some time ago.* The apparatus when fully charged will allow of about three hours' work.

Dræger.—The Dræger apparatus (figs. 6, 7, 8, 9, and 10, plate viii.) is of the type employing compressed oxygen, and can be worn either with smoke-helmet and breathing-bag or with a mouthpiece, eye-glasses, and nose-clip, and a similar breathing-bag; the same back-apparatus being used in each case. The back-apparatus comprises the carrying-frame and shoulder-straps, oxygen cylinders, gauge, and pressure-reducing valve with injector, the surface-cooler, and the regenerating cartridges. The oxygen-cylinders, which have each a capacity of 7,320 cubic inches (120 litres), should be charged to a pressure of 125 atmospheres, and the reducing-valve allows of a regular supply of 122 cubic inches (2 litres) of air per minute. The regenerating cartridges are the means of effecting a radical absorption of the carbonic acid in the expired air, and are an important feature of the apparatus. Two flexible tubes connect the back-apparatus with either the smoke-helmet and breathing-bag or with the mouthpiece and breathing-bag. The smoke-helmet is so constructed as to fit the face of any wearer, a pneumatic cushion, inflated by an air-pump attached to the apparatus, forming an airtight joint between the helmet and face, this at the same time relieving undue pressure of the helmet on the head of the wearer. A mica window, of such a size as to allow a wide range of view, in all directions, is fitted in a favourable position, and an air-valve is provided, this being kept open until the noxious zone is reached and a saving of oxygen thus effected. The mouthpiece, made of rubber, is quite comfortable, and cannot easily slip out of the mouth; the closing of the nostrils being effected by means of a nose-bag

* "Liquid Air and its Use in Rescue-apparatus," by Mr. Otto Simonis, *Trans. Inst. M. E.*, 1906, vol. xxxii., page 534.

with screw-clasp, held in position by means of a head-band. The breathing-bag, fastened to the chest by two shoulder-straps and a waistband, is connected either to the smoke-helmet or to the mouthpiece by two flexible tubes, one for the fresh and the other for the expired air, with, of course, two breathing-valves. The whole bag can be easily taken to pieces for cleansing and disinfecting purposes. Circulation is effected by the injector which, using the live power of the compressed oxygen, sucks the expired air from the smoke-helmet or mouthpiece, respectively, into the exhalation-bag and thence through the regenerating cartridges. After passing through the cartridges, the air, which, owing to the chemical action, has become warm, flows through the surface-cooler and receiving a fresh supply of oxygen is reinhaled. The breathing-bag is provided with a safety-valve, which opens automatically, when the bag becomes too full of air, owing to the quantity used being small. The apparatus, when fully charged, will allow of about two hours' work, it being necessary to employ a triple cylinder should a longer period of work be required.

Fleuss-Siebe-Gorman.—The Fleuss-Siebe-Gorman apparatus* (figs. 11, 12, 13, 14, and 15, plate ix.) is also of the type employing compressed oxygen and can be worn with mouthpiece, eye-glasses, and nose-clip; with a half-mask, which covers nose and mouth, and eye-glasses; or with a complete mask, covering nose, mouth, and eyes. The whole apparatus hangs from shoulder-straps, and is steadied by a waistband. The back portion carries the oxygen-cylinders and reducing-valve, the oxygen-cylinders being charged to a pressure of 120 atmospheres, each cylinder having a capacity of 7,625 cubic inches (125 litres); and the reducing-valve ensures the regular delivery of the requisite quantity of oxygen, irrespective of the pressure in the cylinders. In addition, either an emergency-valve or a bye-pass on the reducing-valve is fitted, in case the wearer should require a greater quantity of oxygen or the reducing-valve were to fail to work. A flexible tube and pressure-gauge is also attached and is carried on the front portion of the apparatus, thus enabling the wearer himself to see the quantity of oxygen remaining in the cylinders. The breathing-

* "Breathing-apparatus for Use in Mines," by Prof. Leonard Hill, *Trans. Inst. M. E.*, 1908, vol. xxxv., page 31.

bag and regenerating chamber form the front portion of the apparatus, being connected with the back portion by a flexible tube, and are of such a capacity as to yield an ample volume of air. The regenerating or caustic-potash or caustic-soda chamber is of vulcanized indiarubber, with a protective covering of canvas, and has exhaling and inhaling divisions to ensure the passage of all exhaled breath through the regenerator, before receiving its supply of fresh oxygen for reinhalation. The caustic potash or caustic soda is placed in such a position that, with each movement of the wearer when walking, the carbonated surface is automatically rubbed off, a fresh surface thus being constantly exposed for the absorption of the carbonic acid gas. The breathing-bag carries a relief-valve, allowing for the escape of oxygen should the bag become too full. The respective headpiece is connected to the breathing-bag by two strong flexible corrugated tubes, the end of one tube carrying the inhalation-valve, the other the exhalation-valve, these being of special metal and very light. The rubber mouthpiece is fitted with a small outer rubber band overcoming the danger of its slipping from the mouth or of possible leakage through it—the nose-clip used in conjunction with the mouthpiece being provided with a device which prevents the possibility of its being inadvertently knocked off. Both the half- and complete-masks are provided with a pneumatic interior ensuring an airtight connection with the face of the wearer. The apparatus, fully charged, allows of about two hours' work.

Weg.—The Weg apparatus (figs. 16, 17, and 18, plate ix.) has already been very fully described in the *Transactions*,* but the present apparatus embodies considerable alterations and improvements. The whole of the apparatus is attached to a jacket, made of moleskin or other strong material, the weight of the apparatus being thus distributed over the shoulders and other parts of the body. The oxygen-cylinders, curved to fit the body, and attached to the jacket above the hips, are coupled together by a copper-pipe, and are charged to a pressure of 120 atmospheres, their capacity, under this pressure, being 9,150 cubic inches (150 litres). A pressure-gauge advises the wearer of the pressure that he is using and

* "A New Apparatus for Rescue-work in Mines," by Mr. W. E. Garforth, *Trans. Inst. M. E.*, 1906, vol. xxxi., page 625.

the quantity of oxygen remaining in the cylinder. The combined reducing and "lung-governing valve" forms one of the principal features of the apparatus; it allows the oxygen to pass as it is required, being operated by the intermittent action of the lungs. A bye-pass to the valve is fitted as a precaution, in case the valve were to fail to act. The oxygen passing through an inhalation-valve travels through a copper pipe to the mouthpiece, which covers both nose and mouth and is provided with a pneumatic lining, allowing of a perfect fit to the face. The mouthpiece is fastened to an ordinary miners' leather cap, being held in position by the inhalation and exhalation-pipes which are carried over the head to the regenerator. An elastic strap attached to each side of the mouthpiece, and buckled to a leather flap at the back of the cap, forms an additional safeguard. The inhalation- and exhalation-pipes, carrying valves, are in the form of a square twin pipe until they reach the back of the head where they branch off, in the form of flexible corrugated pipes, to the regenerator. The regenerator, containing caustic potash or caustic soda, is in the form of a curved rectangular metal case, and is carried on the back, and the vitiated air, after passing through it, enters a pure rubber reservoir-bag, attached to the inside of the lower portion of the jacket, whence it travels by the inhalation pipe to the mouthpiece. A small telephone is fitted to the apparatus, enabling the wearer to communicate with rescuers outside the noxious zone. The apparatus, when fully charged, will allow of two-and-a-half hours' arduous work, or of a longer period should the wearer not be exerting himself.

Westphalia.—The Westphalia apparatus (figs. 19, 20, and 21, plate x.), like the Dræger, is of the compressed-oxygen type and can be worn with either smoke-helmet or mouthpiece, to which is attached a nose-cap. This apparatus hangs from the shoulders, the back portion comprizing the oxygen-cylinders, pressure-gauge, and reducing-valve, while the regenerator and breathing-bags form the chest-portion. As usual, the oxygen-cylinders are charged to a pressure of 120 atmospheres. The oxygen, after leaving the cylinders, passes to the reducing-valve, before reaching which a pressure-gauge advises the wearer as to the amount of oxygen in the cylinders. Passing through the reducing-valve, which ensures a regular supply, the oxygen is forced by the in-

jector through a flexible tube, carried under the right arm to the inhaling-bag and thence to the mouthpiece. The exhaled air passes to the exhaling-bag and regenerator, a rectangular curved metal case, and thence through a flexible pipe, carried under the left arm to the injector-junction, where it mingles with the fresh oxygen for re-inhalation. A blow-off valve is provided just after the reducing-valve is passed, as the apparatus furnishes considerably more air than is required under ordinary operating conditions. The caustic-potash or caustic-soda regenerators are furnished either completely filled and to be thrown away after use, or with a removable cover so that fresh charges may be inserted. The nostrils are closed with plugs of cotton-wool, previously soaked in a suitable grease, and are prevented from falling out by the leather nose-cap, which is fastened to the head with light straps. The nose-cap also being attached to the mouthpiece prevents the latter from dropping out of the mouth, and has no relation to the exclusion of air. The mouthpiece is divided by a thin metal partition, the upper division carrying the air for inhalation, the exhaled air being sucked away through the lower one. The smoke-helmet is provided with a rubber lining to ensure perfect fitting to the face, and is provided with a suitable glass window, but is not furnished with any valves. The apparatus, when fully charged, will allow of about two hours' work.

The trials were successfully completed by four types of apparatus, the exception being the Aerolith, the wearer of which was compelled to withdraw from the trials, owing to lack of air, due to the apparatus not having been properly adjusted.

The results of the trials are recorded in the annexed table.

The thanks of the members of the Institute are due to Mr. C. B. Palmer, for arranging the demonstrations; to Drs. J. W. Mackay and W. L. Ruxton; to Messrs. Henry Armstrong, J. B. Atkinson, P. Phillips Bedson, R. B. Clark, J. J. Simonds, and E. Seymour Wood, who, with the late Mr. M. Walton Brown, assisted by Mr. Percy Strzelecki, acted as observers; to Messrs. W. E. Garforth, Alex. L. Gibbon, W. D. Lloyd, and A. T. Winborn, who generally assisted in the demonstration; and to Mr. Harry Dean for kindly taking photographs of the various apparatus (plates viii., ix. and x.).

RESULTS OF EXPERIMENTS WITH VARIOUS TYPES OF RESCUE-APPARATUS FOR MINES.

Apparatus.	Weight.		Wearer.							Time adjusting apparatus to wearer.	Smallest opening through which apparatus can pass.	Time occupied in completing trials.	Time taken to re-charge apparatus.	Remarks.
			Weight.	Temperature.		Pulse.		Respirations.						
	Empty.	Charged.		Before trials.	After trials.	Before trials.	After trials.	Before trials.	After trials.					
	Lbs.	Lbs.	Lbs.	Degs. Fahr.	Degs. Fahr.	Per minute.	Per minute.	Per minute.	Per minute.	Minutes	Inches	Minutes	Minutes	
Aerolith	14	20	141	98·2	99·2	82	120	24	22	—	—	—	—	Wearer compelled to withdraw, owing to lack of air, due to apparatus not being properly adjusted, as no one experienced in its use was present.
Dræger: helmet-type.	36	40¾	156	98·2	98·7	100	110	24	25	2	17	69	1	—
Dræger: mouth-piece-type.	—	36¼	146	98·2	99·2	94	—	26	22	1	16	76	1·6	—
Fleuss - Siebe - Gorman.	26	30	164	98·4	97·4	84	132	24	22	2	14	57	2·05	While in the carbonic-acid chamber the competitor forgot to open valve of second cylinder, and, showing signs of exhaustion, was withdrawn. He immediately realized his error, and, rectifying it, re-entered the chamber and completed the test. The high pulse-rate might probably be due to excitement caused by his misadventure.
Weg	—	38½†	148	99·2	98·4	76	98	20	22	—	17‡ 15§	61	7½	—
Westphalia: helmet-type.	—	36	162	98·4	98·7	100	77	26	20	—	20	69	—	No re-charge, and therefore did not enter chamber filled with sulphur-dioxide fumes.
Westphalia: mouth-piece-type.	36¼	38¼	154	98·2	97·6	104	110	24	24	—	20	61	—	Mouthpiece came off during the trials, but was at once replaced. No re-charge, and therefore did not enter chamber filled with sulphur-dioxide fumes

* The times under this heading are not of much value, as in several instances competitors were compelled to wait, owing to the man in front not having completed his task.
† Including jacket. ‡ Without loosing jacket. § After loosing jacket.

Mr. T. B. A. Clarke (Hoyland Common) wrote that there was so much interest taken at the present moment in mining rescue-apparatus as a means of dealing promptly and effectively with accident, that everyone who might have to deal with such sudden catastrophes would appreciate the record of the results of the experiments carried out at Felling. Trials were being carried out in the various coal-fields of Great Britain and also in the Colonies: and, in criticizing the tests carried out at Felling, he (Mr. Clarke) was of opinion that they were not exacting or severe enough to test fully the capacity of the apparatus or the endurance of the wearers.

The principle of supplying liquid air from a reservoir did not seem as yet to be practical or reasonably reliable, but the various types of rescue-apparatus which depended on a supply of compressed oxygen would appear to effect the desired result. Of the types described and illustrated in the paper, four were practically the same in principle, though differing, of course, in details.

He (Mr. Clarke) thought that it was not sufficient merely to have a number of rescue-appliances at a station. The equipment should be complete, and should include all spare parts of the apparatus itself, an auxiliary pump for rapidly refilling the working-cylinders, a reviving apparatus, and a special stretcher with oxygen equipment for conveying an injured person to a point of safety.

H.M. Inspectors of Mines would no doubt be anxious and willing to co-operate with the colliery managers in the various coal-fields, with a view to the establishment of rescue-stations at suitable points. In addition to this, every colliery should have an installation of its own on a smaller scale, to enable them to deal promptly with any sudden emergency, though it would subscribe its quota to the central rescue-station and send its own men to be trained in the gallery attached thereto. Having received this training, the men would then perform regular drill at their own colliery in a manner similar and as an adjunct to the ambulance work now being carried on. In order, therefore, to deal effectively with any catastrophe, the following desiderata were, in the writer's opinion, essential: —

(1) Oxygen rescue-apparatus which had successfully passed the severest tests, and could be easily kept in a condition to do so again at a moment's notice.

(2) A corps of men of good physique and intelligence, ready to wear it with the least possible delay, and thoroughly trained in its use and in the use of all supplementary appliances.

(3) Supplementary spare parts, a reviving apparatus, a special stretcher, and an auxiliary pump for rapidly refilling the oxygen-cylinders.

Given a reliable installation, and a means of applying it at once in case of accident, the best results should be obtained with a minimum of risk to the rescue-party. The condition of (1) the heart, (2) the lungs, and (3) the urine of the wearers, when examined medically after a severe test, afforded an index to the merit of each apparatus.

The general opinion was that a rescue-party should consist of five persons, so that to deal with a sudden contingency each colliery should have five sets of apparatus ready to be at once put into use in case of need. The local rescue-party would make a preliminary examination, and by the promptness of their services would probably avert serious disaster. Meanwhile the central rescue-station would be telephoned to, and a party with all necessary reserves of apparatus would proceed immediately to the scene of the accident; they would then be able to receive the report of the pioneer party and replace it for another spell of about 2 hours' work. The writer considers it essential that every rescue-station should be equipped with a telephone, and also with a suitable motor-car to carry men and apparatus.

Mr. Henry Simonis (London) wrote that in the Felling experiments the Aerolith apparatus did not give satisfactory results, because there was nobody on the ground who understood it or who had ever worn the apparatus, and later investigations had shown that it was fitted on wrongly. He contended that the principle of this apparatus was the correct one, as rescue-apparatus should be air-generating and not regenerating. A liquid-air plant was now established at Newcastle-upon-Tyne, and this would materially assist the Tyne collieries if the Aerolith type of apparatus were adopted.

Mr. John Padbury (Stockton-upon-Tees), referring to the results with the Dræger apparatus, stated that there was evidently some mistake as to the weights recorded, as the actual weight of the helmet-type of apparatus, when charged, was only

from 37 to 38 pounds and not $40\frac{3}{4}$ pounds as noted in the table. He thought that the tests could not be considered conclusive, as it was impossible to test satisfactorily such apparatus in a natural atmosphere. More recent tests in Lancashire had proved adequately that using an apparatus under natural conditions and using it in an irrespirable atmosphere were two quite different things. Another point to be considered was the difference between highly trained and less efficient men wearing the apparatus. The former might be able to wear it for two hours, whereas the latter might not be able to wear it for half-an-hour. An apparatus which could be worked by a man without previous training had a decided advantage, and long experience had shown that the advantages or disadvantages of the various types of apparatus could not be demonstrated by exhibitions in which the makers' own men competed. The only way to come to a correct conclusion was to try the appliance on oneself, as only then could the faults of any particular apparatus be detected. Since he had been brought into contact with mining men, he had abandoned the idea that it was better in mining rescue-work to have persons who had been specially trained in the use of the apparatus, as he now felt that it was only by having trained pitmen that any good could be done through wearing the apparatus.

Mr. J. B. Atkinson (H.M. Inspector of Mines, Newcastle-upon-Tyne) said that he was not aware that there was a liquid-air plant in Newcastle-upon-Tyne, and perhaps it would be as well that the members should know where it was situated.*

Dr. W. L. Ruxton (Newcastle-upon-Tyne) said that he had examined a number of the Felling competitors before they had commenced their tasks, and his remarks would therefore be offered from a medical point of view on the facts elicited. The paper contained a table in which were given the temperature, pulse and respirations of the men before and after the trials, but the instances were too few in number to furnish a reliable guide as to the effect of substitutes for atmospheric air, or to indicate clearly the advantages and disadvantages of one apparatus over another. It would be noticed that the temperature was generally a little higher after the trials, but the amount of physical

* The liquid-air plant referred to is that installed by the British Oxygen Company, Limited, Boyd Street, Newcastle-upon-Tyne.—Editor.

exertion involved was sufficient to account for the increase, and probably this was the explanation. The pulse-rate was also increased, and this might also be attributed to the same cause. In one instance, the pulse-rate was 100 before and 77 after the experiments; this might be accounted for by the fact that the man was not examined immediately after the tests, and he had probably therefore had sufficient time in which to recover. There was no difficulty with regard to respiration, except in the two cases mentioned in the table, due to the reasons stated.

Referring to the examination of the men, he personally examined six or eight of the candidates, three of whom he had to reject. They all looked physically well, but one had a very high temperature, and had evidently commenced to suffer from the effects of a disease of some sort; another had a heart murmur; whilst the third was too excited and nervous. As regards excitement and nervousness, the man who forgot to turn on the cylinder was probably the most composed of the lot, and yet he lost his self-possession during the trials. He (Dr. Ruxton) felt justified in suggesting one or two essentials in the character of men using rescue-apparatus. In the first place, it was desirable that the men should not be novices, for that accounted largely for the nervous trepidation; anticipation made them excited, and that might be detrimental to their using the means at their disposal. Secondly, physical fitness was absolutely necessary; they must have an absolutely physically good man, and a cursory examination was not sufficient, but every organ should be carefully examined, especially the heart and respiratory organs; and it should be seen that the man had an ample chest capacity for breathing purposes. Thirdly, the man's temperament should be unexcitable and his resource in difficulties good. Fourthly, youth, or at least a man under 40, was very advisable, and temperance was essential. The men selected should be examined at intervals of six to twelve months, and if possible immediately prior to their undertaking rescue-work in foul air, with the object of obviating the possibility of a physically strong man, temporarily indisposed, being allowed to take part therein.

Mr. W. C. Blackett (Sacriston) said that he had no remarks to offer upon any particular apparatus, but what he had to say

was with reference to such apparatus generally; and it might strike some as being a peculiar question when he asked: What was the purpose for which such rescue-appliances were being so prolifically designed? It seemed to him that there was far too great a tendency at the present time on the part of nearly everybody, with the exception of the few who were the best able to judge, to come to the conclusion that if they could only get "rescue-apparatus" they were going to save a number of lives. It seemed to him that the name given to such appliances was rather delusive. Their sapient law-givers readily rose to the bait, and rescue-apparatus might so attract their notice as to result in laws being passed under false impressions. There might sometimes arise occasions when apparatus of this kind might be useful in mines, but in the whole course of his own experience of mines after explosions he had not come across one single instance where such apparatus would have been of the slightest use. This was rather a sweeping statement, but his experience might not have been so wide as that of others. It struck him that it was not necessary, when an explosion or an underground fire occurred at a colliery, for people to rush away and put helmets on. What was wanted was to enter the mine carefully, and ascertain what the conditions were before doing anything else; and then, before using breathing-apparatus of any kind, they wanted to know where they were going and very definitely for what purpose. Breathing-apparatus was only available for two or three hours, and it was no use putting it on to walk about the pit without knowing what one was going to do. If they knew that beyond a certain foul-air barrier there was a man alive, who could be got out through some extraordinary circumstances, of which he must confess, he had not hitherto had experience, they might put on one of these things for the purpose of getting him out. Even if they did get through the bad air and found somebody alive, they would have to fit him up in a similar fashion or remain with him. He had never yet heard of a single person who had been rescued by means of these appliances, which he first saw in use after the Seaham colliery-explosion in 1880; but both at Courrières and, more recently, at Hamstead the use of such apparatus had resulted in loss of life, and this was the point that he wished to bring out. As to training men in the use of such apparatus, it would be advantageous, provided that

they could keep them trained and the apparatus in order for the long periods of time during which they were not required; for it was during such periods that the men were likely to become heartily sick of the drill and discipline, through not being of actual use. He could imagine, however, such appliances being ten times more useful elsewhere than down the pit, and a disciplined corps of men who could go anywhere would be more useful than a trained band of men for mines only. They might even train colliery men who would not be of much use down a colliery with which they were not familiar. As regards the training generally, to men advanced in years this would no doubt become irksome and be neglected.

Mr. J. B. Atkinson said that he agreed with a good deal of what Mr. Blackett had said upon this question, and in particular with the statement that many people not acquainted with mining —amateur mining experts, so to speak—thought that there would be a great saving of life by the use of such apparatus, and that if in the case of a colliery-explosion they had a corps of men ready with rescue-apparatus they would bring most of the men out of the mine alive. That, he believed, was an absolute delusion. He had not had direct experience of any colliery-explosion regarding which he could say that the use of such apparatus would have saved any lives; certainly, not the lives of any of those who were in the pit at the time when the accident occurred, although there might perhaps have been some occasions when explorers had gone in too far and had been overcome who might have been rescued. Notwithstanding that, he thought that such appliances might have a use; and he would be sorry to see their development checked by the Institute throwing cold water upon the question. There were cases of fires in mines where appliances of the kind might be useful. When he was in Scotland a fire had occurred at a colliery there* where 63 lives were lost, and a long time was spent in trying to get a door closed owing to the smoke pouring out on to the intake airway from the return airway. In that case rescue-apparatus might have been useful, as it would have enabled the wearer to go in and close the door,

* *Report of H.M. Inspector of Mines for the East Scotland District (No. 1) to Her Majesty's Secretary of State, under the Coal Mines Regulation Act, 1887, the Metalliferous Mines Regulation Acts, 1872 and 1875, and the Slate Mines (Gunpowder) Act, 1882; for the Year 1889*, by Mr. J. B. Atkinson, London, 1890, page 34.

which would have prevented the smoke from passing into the intake and right round the workings, and possibly there might have been some lives saved. In other cases in Scotland, gases from spontaneous fires had caused loss of life, but he did not know that the use of the apparatus even there would have been the means of saving anyone, though it would have enabled the rescue-party to get to the place sooner than they were able to do. With reference to the case at Hamstead colliery, where the person using the apparatus succumbed, this was probably in consequence of heat apoplexy. He had gone into air heated beyond the normal temperature, and probably had not sufficiently recognized that fact. A man wearing one of these appliances might be all right in smoke, so far as the smoke was concerned, but the effect which the heat would have upon him must be borne in mind, especially when, in using the apparatus, he was already under somewhat abnormal conditions.

Mr. E. Seymour Wood (Murton) said that he was present at these so-called tests, but from his observations he would say that they were simply experiments and unreliable, and were not tests which could be recorded as results of what could be done with the different appliances under actual conditions. He noticed that several of the men during the tests were not even using the apparatus at all, but were resting. The conditions there were quite different from those to be found in a mine containing foul air. If reliable results were to be obtained, tests should be made in a gallery filled with smoke, or in a noxious atmosphere.

Mr. Frank Coulson (Durham) agreed that the apparatus under certain conditions might be very useful. He also agreed with the remarks of Mr. Blackett and Mr. Atkinson: it was useless to rush inbye to get men out, but he thought that they would be more quickly got out if the men wearing the apparatus were to go in front of the fresh air and erect stoppings and clear falls, etc. On this subject it occurred to him that the proper course would be to take fresh air in; and to have a station with appliances for fans or air-compressors driven by motors, which could be taken at once to a colliery where there had been an explosion, when, with a proper construction of air-pipes, the air could be injected inbye very rapidly; the apparatus could be put down the shaft and slung with chains and be put on the ways

as soon as these could be got ready, and in that way they would probably be able to get men out.

Mr. J. J. Simonds (Newcastle-upon-Tyne) said that in connection with the fire-department of the Elswick works of Sir W. G. Armstrong, Whitworth & Company, Limited, they had one of the types of helmet described in the paper. They had never been asked for its use in mines, but it had saved life elsewhere, and had on several occasions proved useful. In one case, in an old tunnel-shaft from a furnace, it was thought that the end had been blocked up, and a man who went in to repair some brickwork collapsed. They were able to get to him with the helmet and to pull him out, and he was resuscitated by means of artificial respiration. Another case where the apparatus was useful was in connection with a refrigerating-apparatus working with ammonia gas. Yet another case was at the Redheugh Gas-works: a valve had become corroded, and it was only by means of a breathing-apparatus that they could get down to close it. Rescue-apparatus would, no doubt, have proved valuable at the fire which occurred at Messrs. Mawson & Swan's premises in Newcastle-upon-Tyne a few years ago, when three firemen died from the effects of descending into a cellar filled with noxious fumes; for with rescue-apparatus they could have gone down quite safely.

With reference to Dr. Ruxton's remarks regarding novices, etc., he (Mr. Simonds) thought that a fire-brigade would have just the type of man whom Dr. Ruxton described. With a trained fire-brigade, it was quite an easy thing to do so many hours' practice in each week, and with regard to the keenness wearing off through the men seeing no chance of saving lives, and the possibility in consequence of their dropping into the background, this could not happen with a permanent brigade. At present there seemed to be very little discipline or order in regard to rescue-work. A party of men would go down the mine, and one would get on in front and perhaps find his supply of air give out. He (Mr. Simonds) would recommend that there should be seven men wearing helmets in each party, six to do the necessary work and one to look after the others; and if it were at all possible it was most necessary that he should be connected by a portable telephone with the pit-mouth; but he did not know

whether it would be feasible for a man to trail a small wire with him so as to be in such telephonic communication. In the training of rescue-parties it should be a distinct factor that one man should be responsible for the others, and of course they would have to obey him implicitly. Another point which occurred to him was that it would be impossible, supposing that they had fifty or sixty men in a fire-brigade, to give them more than a very cursory idea of what a mine was like; and even miners could not know every mine. It seemed to him that they would have to find someone belonging to the pit in question, who would go down with the rescue-party to show them the way about and to take charge. The firemen would be in charge of the apparatus and would see that it was in the best of condition, but some such person who knew the place would have to be provided at the pit to instruct them as to the work to be done.

Mr. J. B. Atkinson remarked that ordinary firemen would not be of much use in a mine.

Mr. W. C. Blackett said that there was a great deal in what Mr. Simonds had said; the general idea was that miners could go right away into pits with breathing-apparatus on, but this was not so. In every one of the instances which had been quoted where rescue-apparatus had proved of value, the men knew exactly what they were going to do before they went in. In one case a man had to shut a door, in another to close a valve, but a trained pitman was not required for such work. It was more than possible that the nucleus for a general breathing-apparatus station already existed in Mr. Simonds' own hands. There certainly were legitimate uses for such apparatus, but they were more analogous to the uses that were now made by expert divers in water. As to Mr. Coulson's remarks, they, of course, must take air in, but it had never been of great use to send men beyond where they could go with a bird or small animal, and air-pumps would be of little or no use. It was the men who went rushing in beyond the stoppings who were overcome; there was no need for it, and they would not usefully get much further even if they had the apparatus on.

Mr. J. B. Atkinson said that, with the exception of the experiments at Seaham, the only occasion that he remembered of the

use of rescue-apparatus in mines in the North of England was when the Fleuss apparatus was employed at Killingworth in the year 1882*; the downcast shaft had collapsed, and the men had to be brought out by the upcast.

Mr. W. C. Blackett: They knew what they had to do.

Mr. T. E. Forster (Newcastle-upon-Tyne): And it was the men who wore the apparatus who were rescued.

Mr. J. B. Atkinson, continuing, said that he did not agree that an ordinary fireman could be sent alone into the mine wearing an apparatus, but he might be taken, as Mr. Blackett indicated, to a definite place for some definite work; he could not be allowed to go any distance, as there were so many dangers—falls of stone, and so on—about which he would know nothing. The idea of a central rescue-station was a good one. In such a station, there could always be half-a-dozen or a dozen miners trained in conjunction with the civilian branch, and they might be very useful. Newcastle-upon-Tyne seemed an ideal place to cover all the collieries in the North of England.

Mr. T. E. Forster thought that there was a good deal in what Mr. Blackett said; even if they had trained firemen and pitmen, it would not be much good, unless they had some of the officials of the mine capable of using the apparatus. If half-a-dozen pitmen were turned loose down the pit, they would not be of much use for exploration; it would, of course, be different if they had a definite purpose in view, such as the opening of a door or knocking a stopping out.

Mr. E. Seymour Wood said that Mr. Simonds' remarks ought to be useful, for he had brought out very fully that a properly disciplined brigade, such as a fire-brigade with a definite object, could be made to do useful work with helmets of different kinds. Absolute discipline was important, and, if that could be obtained, cases would be found where such a brigade might be of service.

* "Report on the Inspection of Mines in the Newcastle-on-Tyne District, comprising the North part of the County of Durham, the Counties of Northumberland and Cumberland, and the detached part of North Lancashire, for the Year ending 31st December, 1882," by Mr. James Willis, *Reports of the Inspectors of Mines, to Her Majesty's Secretary of State, for the Year 1882*, London, 1883, page 318.

Mr. J. J. Simonds said that was the point which he wanted to get at. They would require a body of thoroughly disciplined men who would not lose their heads, led by an official of the colliery, with a definite object, and with apparatus which from experience each fireman knew was in perfect condition. The danger of the amateur element was that the apparatus might lie unused for several years and get out of order.

Prof. Henry Louis (Armstrong College, Newcastle-upon-Tyne) reminded the members of Mr. G. A. Meyer's paper on the Courrières disaster;* in that case a party of men who, as Germans, had the advantage of having been disciplined by military drill, and who carried telephones in with them, had entered the mine, but the only thing that was effected by the use of rescue-appliances was to lose the life of one of the rescue-party.

Mr. H. W. G. Halbaum (Horden) wrote that he had anticipated, some five or six years ago, the very dangers, etc., to which Messrs. W. C. Blackett and J. B. Atkinson had called attention.† He had then noted the imperfection of such apparatus; and had pointed out the danger, since unhappily demonstrated in practice, of the wearer suffocating himself instead of rescuing others; he had anticipated Mr. J. J. Simonds' idea that disciplined firemen might penetrate a mine, and also Mr. Atkinson's objection that they would do so at their peril. Firemen were, no doubt, among the bravest of men, but, like other men, they were bravest in facing familiar dangers, and the dangers of a mine could only be safely tackled by experienced pitmen. He had likewise anticipated Mr. Blackett's observations anent the danger of turning helmeted men adrift in an exploded mine, without settled and definite plans of action, and the same gentleman's deprecation of the idea of seeking the living among the dead, and of the fallacy of going before the air to put in stoppings, etc. In his concluding remarks he had viewed the case from the standpoint of the practical pitman, and had shown how rescue-operations might be conducted both sanely and safely, and without introducing new perils of the kind referred to. He was glad to have his opinions supported by Mr. Blackett.

* "Rescue-apparatus and the Experiences gained therewith at the Courrières Collieries by the German Rescue-party," by Mr. G. A. Meyer, *Trans. Inst. M. E.*, 1906, vol. xxxi., page 575.

† *Trans. Inst. M. E.*, 1902, vol. xxiv., page 175.

Prof. Thomas Oliver, M.D. (Newcastle-upon-Tyne), wrote that it was a disappointment that he had found himself unable to be present at the demonstration with rescue-apparatus at Felling, especially as he had had the opportunity, through the kindness of Mr. W. E. Garforth, of witnessing the experiments carried on at Altofts colliery, near Normanton. So far as concerned the various forms of apparatus, he was only acquainted with the Weg, the Dræger, the Aerolith, and with the Vanginot apparatus, which latter he had seen worn by the fire-brigade men (*sapeurs et pompiers*) in Paris. As there had been recently held another demonstration in Lancashire to settle the question, he would not express an opinion as to the superiority of one form of rescue-apparatus over another.

The main point to be considered was whether it was possible for men wearing safety-apparatus to reach and rescue miners in a pit after an explosion. To accomplish this, several dangers and difficulties had to be overcome. There were not only the dangers and immediate risks to life consequent upon the presence of poisonous gases, but those attendant upon extremely high temperatures and which might be a cause of "heat-stroke." That "heat-stroke" itself might become a cause of death had been placed beyond all doubt. That rescue-apparatus could be worn with safety by men when surrounded by poisonous gases had been fully demonstrated by the experiments which he had seen at Altofts colliery. The men who wore the Weg apparatus were in the poisonous atmosphere of the gallery for fully two hours; during that time they underwent considerable hardship, and experienced such muscular fatigue as would be felt by rescuers in a mine after an explosion. When they came out, the men seemed none the worse for the physical strain which they had undergone. The possibility of accomplishing something of what would have to be undertaken in a mine after a colliery explosion had therefore been realized. If rescue-work by safety-apparatus was to be attempted, it was clear that the men must be trained, since a certain degree of nervousness in the early stages had to be overcome, a degree of self-confidence cultivated, and, above all, faith established in the reliability of the apparatus itself; and this experience and knowledge alone could supply. It seemed to him that the time had come when colliery proprietors and mine managers must face the problems of life-saving apparatus and

ascertain of what assistance science could be to them in the matter. The demonstrations at Felling and elsewhere had shown what could be done, also what were the possibilities of failure: but it was through a careful study and appreciation of failures that success was ultimately attained. While the use of safety-apparatus might not always allow of a rescue-party reaching miners in a pit and in saving them, it might enable the rescuers to reach particular parts in a pit after an explosion, whereby they might succeed in diverting air-currents or in mending machinery which had gone wrong. It was when entombed miners had been reached by a rescue-party and the men were found to be unconscious that fresh difficulties arose. The men thus found would have to be removed to another part of the pit freer from gas, wearing masks similar to those of the rescuers, and be hurried out of the mine altogether; or some other apparatus would have to be employed to remove the poisonous gases from the blood. Under any circumstances it was advisable that the men who undertook the rescue-work should know the particular mine in question.

The PRESIDENT (Mr. John H. Merivale) said that the thanks of the members were due to Mr. Claude B. Palmer for the trouble and expense which he had incurred in arranging the experiments, to Mr. Lawrence Austin for his valuable record, and to Dr. Ruxton and other gentlemen for the assistance that they had given. Personally, he was pleased to find that after the age of 40 one was not expected to wear the apparatus. He had once tried one on, and certainly felt the nervous excitable feeling alluded to: but he was not sure that the man who was nervous at first was not better than the man who started with more assurance. He sympathized with the suggestion that they did not want any more legislation in connection with mines in the North of England. Although at first sight there might not appear to be a great deal to be got out of rescue-appliances, it was their duty to foster anything that advanced knowledge. They were not merely an Institute of mining engineers: they had a much broader foundation than that; and though at present it did not seem likely that such apparatus could be of much use in mining, they had heard that in other branches of industry the apparatus had been of service in the past, and probably would be so in the future. He thought,

therefore, that it would be wise for them to support the proposal for having some central station with men trained in the use of the various types of so-called rescue-apparatus. Perhaps Mr. Simonds, with his practical knowledge of the matter, would be prepared to write a paper dealing with the organization of such a central station. In conclusion, he moved that the thanks of the members be accorded to Mr. C. B. Palmer for arranging the experiments, and to Mr. Lawrence Austin for his record of them.

The votes of thanks were carried unanimously.

Mr. Thomas Harker's paper on "Flinty Chert, Hornstone, etc.," was read as follows:—

FLINTY CHERT, HORNSTONE, ETC.

By THOMAS HARKER.

Character.—Flint may sometimes be observed passing into a substance of a more opaque and earthy nature, but equally hard. This substance, which has received the name of chert, or hornstone, may be regarded as an earthy variety of flint. Chert is always of a hardness sufficient to scratch steel or glass, and, when not porous, has a specific gravity ranging from 2·55 to 2·65. It is insoluble in all acids, with the exception of hydrofluoric acid, and is infusible before the blow-pipe.

Geological Distribution, etc.—All the chert which is being worked in England and Wales occurs in the Carboniferous Limestone Series or in the Millstone Grit. It also frequently occurs in large masses in and below the Chalk. In the Yoredale strata it is found, as a general rule, between the limestone and the plate (shale) and sandstone-beds, next above it. In the southern counties of England, the same mass of chert presents the appearance of perfect chalcedony in one part and of flint in the other, showing the near connexion of these minerals, which are in reality only different varieties of the same substance. In Derbyshire, where the chert occurs in the Mountain Limestone, the flint differs greatly from the flinty chert of the northern and southern counties. It appears to have undergone some chemical change during its formation, and is fusible.

Chert-mining is, at the present time, carried on at Bakewell in Derbyshire, in the Halkyn mountains in Flintshire, and in Swaledale in Yorkshire. There are five distinct beds of chert in the North Riding of Yorkshire, all somewhat different in nature, as follows:—(1) Flinty chert, 16 feet thick, lying 87 feet below the Millstone Grit; (2) Crow chert, 6 feet thick, lying 6 feet below the Flinty chert, the intervening strata being plate; (3) Second Crow Chert, 15 feet thick, lying 6 feet below the Crow chert, the intervening strata again being plate; (4) Main

chert, 18 feet thick, lying 196 feet below the Second Crow chert and only 18 inches above the Main or Twelve-fathom limestone, the strata immediately above it being plate, 4 feet thick; and (5) Undersett chert, 24 feet thick, generally of a hard nature and very much darker in colour than the other beds, lying 60 feet below the Main or Twelve-fathom limestone and 6 feet above the Undersett limestone, the strata immediately above and below being plate, 22 feet and 6 feet thick respectively.

On the western side of the valley of Arkingarthdale most of the cherts have proved very productive in lead-ore, whilst on the eastern side of the dale they have proved practically unproductive. It is remarkable that the Undersett chert, which is being worked in the neighbourhood of Reeth, on the eastern side of Swaledale, produces some of the finest flinty chert, of the same nature as that worked on the western side of the dale, but the latter bed lies no less than 100 feet higher up in the series. The writer is not aware of any other locality where the Undersett chert is of such a flinty nature as at Reeth, chemical change no doubt being the cause.

Analyses.—The following analyses of chert sold to the Potteries are taken from Mr. Hubert L. Terry's paper on "Chert-mining in England and Wales":—*

	Derbyshire.		Swaledale.	Flintshire.
	Per cent. (1)	Per cent. (2)	Per cent.	Per cent.
Water	0·54	0·60	1·61	1·32
Silica	82·53	63·40	95·69	93·56
Ferrous oxide	—	—	1·02	4·52
Ferric oxide	1·05	2·34	—	—
Carbonate of lime	15·88	33·66	1·86	0·43
	100·00	100·00	100·18	99·83

Use of Chert.—For the inception of its mining, we must go back to about the year 1777, when Wedgewood initiated the use of flint in the manufacture of pottery, and Brindley invented the wet-grinding pan, this being its only application of importance. Large quantities of chert are now yearly sent to Staffordshire for the Potteries district, thousands of tons being sent from Reeth alone.

---

* *Transactions of the Institution of Mining and Metallurgy*, 1906, vol. xv., page 555.

Mr. Bennett H. Brough (London) thought that for purposes of comparison it might be useful to add to the interesting series of analyses of chert sold to the Potteries the best known Continental analysis, that by Ricciardi of a sample from Sicily, which was found to contain 96·31 per cent. of silica, 0·30 per cent. of alumina, 0·25 per cent. of ferrous oxide, 0·47 per cent. of lime, and 2·81 per cent. of water. The inception of the mining of flint was much earlier than the initiation of the use of flint in the manufacture of pottery in 1777. In the Stone Age flint was mined for tools and weapons in East Anglia, and mining still continued at Brandon, in Suffolk, for the purpose of supplying gun-flints for savage tribes. The method of mining the flint and of preparing the gun-flints was described in 1879, by Mr. Sydney B. J. Skertchly.*

Mr. J. B. Atkinson (H.M. Inspector of Mines, Newcastle-upon-Tyne) said that Mr. Harker's paper was an interesting geological contribution, and he would like to know the scientific definition of chert. Chert occurred in the Carboniferous Limestone of Swaledale; what were the corresponding beds in Northumberland and Durham? It struck him that the gannister beds might correspond to the chert-beds, and that the stratum called "tuft" in the lead-mining districts was of the same nature, though apparently not so solidified or bound together as the chert. According to the analyses given in the paper, the two samples of chert from Derbyshire contained a considerable proportion of carbonate of lime; whilst that from Swaledale contained only 1·86 per cent., and that from Flintshire 0·43 per cent. Should lime be considered as one of its constituents?

Prof. Henry Louis (Armstrong College, Newcastle-upon-Tyne) said that he had seen the Swaledale chert-beds worked in the neighbourhood of Richmond, where they occurred in the upper beds of the Mountain Limestone. He did not think that carbonate of lime was an essential constituent. Chert was probably a hydrated silica, but he did not know that any precise definition had ever been laid down.† The oxide of iron was a

* *Memoirs of the Geological Survey of England and Wales: On the Manufacture of Gun Flints, the Method of Excavating for Flint, the Age of Palæolithic Man, and the Connexion between Neolithic Art and the Gun-flint Trade*, by Mr. Sydney B. J. Skertchly, 1879.

† The definition given by Mr. J. D. Dana (*A System of Mineralogy*, fifth edition, 1872, page 195) is the conveniently vague one of "any impure flinty rock."—H.L.

serious disadvantage in chert used for pottery purposes; chert should be as free as possible from this, as it had a very deleterious effect on its colour properties. He did not quite agree with the author's view that chert occurred in large masses in and below the Chalk. He believed that what they got in the Chalk were flints, which were distinctly different in their mode of occurrence, and were, moreover, mostly, if not always, of organic origin; but he confessed that his knowledge of the subject was limited. He did not associate chert with gannister.

Mr. J. B. Atkinson said that a bed of gannister was being worked, near Fourstones, which was closely associated with the Great Limestone, very much as the chert-beds were in Swaledale.

Prof. H. Louis said that he thought that their mode of occurrence was essentially different.

Mr. W. M. Egglestone (Stanhope) wrote that there were no chert-beds in the Mountain Limestone strata forming the lead-measures of Weardale. Whilst the main chert-bed of Swaledale, in Yorkshire, overlay the Main Limestone, the beds overlying the Main or Great Limestone of Weardale were, in ascending order, shale or plate, low-coal sill, sandstone, coal, shale, high-coal sill, coal, shale, Little Limestone, etc. Nattriss-gill hazle, a close-grained sandstone, underneath the Four-fathom Limestone, and some 44 feet below the Great Limestone, was, with other sandstones, the gannister of Weardale. At Wolsingham, down the Wear valley, good gannister was quarried not far below the Millstone Grit.

Chert, according to Mr. Bradley,* was a siliceous and to some extent calcareous deposit, and, in an analysis given by him, carbonate of lime figured at 37·49 per cent. One writer pointed out that chert was less splintery than flint, and was fusible, suggesting that the latter quality might be due to its containing a little lime. Chert appeared to have resulted from the solution and redeposition of the silica of certain fossils, such as diatoms, sponges, etc. Radiolarian chert was associated with shales and limestones in Mullion Island, off the western coast of the Lizard in Cornwall.†

* *An Inquiry into the Deposition of Lead-ore in the Mineral Veins of Swaledale, Yorkshire*, by Mr. Lonsdale Bradley, 1862, page 4.

† *The Physical Geology and Geography of Great Britain*, by the late Sir Andrew C. Ramsay, sixth edition, edited by Mr. Horace B. Woodward, 1894, page 67.

Referring to the Bakewell mineral, in Derbyshire, "it is more truly intermediate between limestone and chert, being a limestone that has been partly replaced by chert."*

Prof. Cole referred to chert as retaining some of the features of the original limestone, and instanced the chert of the Assynt Limestone at Stronechrubie, Sutherland, as preserving in the most exquisite manner the oolitic structure that doubtless once prevailed throughout considerable masses.†

The flints used by Palæolithic and Neolithic man for their implements of war, etc., were evidently from the Chalks, and it might be asked whether the flints which Mr. Astbury, a Staffordshire potter, who was credited as being the first to introduce flints to the Potteries in 1720,‡ were not also Chalk-flints. These flints appeared to have been formed by the aggregation of siliceous matter around various organisms which served as nuclei, whilst the mode of occurrence of the Carboniferous Limestone cherts, referred to in Mr. Harker's paper, appeared to have been, as Prof. Henry Louis had said, distinctly different.

On the motion of the PRESIDENT, a cordial vote of thanks was passed to the writer of the paper.

The following paper by Mr. WILLIAM MORLEY EGGLESTONE on "The Occurrence and Commercial Uses of Fluorspar" was taken as read:—

* *Memoirs of the Geological Survey of England and Wales: The Geology of the Carboniferous Limestone, Yoredale Rocks and Millstone Grit of North Derbyshire*, by Messrs. A. H. Green, C. Le Neve Foster, and J. R. Dakyns, second edition, with additions by Messrs. A. H. Green and Aubrey Strahan, 1887, page 166.

† *Aids in Practical Geology*, by Prof. Grenville A. J. Cole, 1891, page 187.

‡ *Handbook to the Collection of British Pottery and Porcelain in the Museum of Practical Geology*, 1893, page 29; and *Chemistry of Porcelain, Glass and Pottery*, by Dr. Shaw, 1837, page 248.

THE OCCURRENCE AND COMMERCIAL USES OF FLUORSPAR.

By WILLIAM MORLEY EGGLESTONE.

I.—Occurrence, Etc.

Introduction.—Fluorspar in England is practically confined to the counties of Derbyshire and Durham, and statistics for recent years show a wonderful boom in this mineral as a commercial product. The "Blue John" of Derbyshire was discovered at an early date, whilst in Weardale, County Durham, fluorspar, as a bye-product, was not considered of any commercial value until recent years; although as a waste-product it has been known in the dale for at least seven-and-a-half centuries.

Government returns show that the output of fluorspar in England during the year 1873 was *nil*, and that during the ensuing twenty-seven years 1,000 tons per annum was only twice exceeded. The figures for the succeeding years are as follows, those relating to the United States of America being also given:—

Year.	United Kingdom.			United States.
	Weardale. Tons.	Quantity. Tons.	Value. £	Tons.
1901	3,309	4,214	2,226	19,536
1902	4,990	6,287	3,486	48,018
1903	5,591	11,911	8,538	42,523
1904	4,435	18,160	15,464	36,452
1905	4,989	39,446	19,557	57,385
1906	14,165	41,849	20,023	40,796

Fluorspar is usually found in metalliferous veins producing galena. The object of this paper is to give some account of its occurrence in Weardale and elsewhere, its characteristics, and its use as a flux in metallurgy.

Description.—Fluorspar, fluorine, fluss-spath, fluorite, or fluor, received its name from the latin *fluo*—to flow, on account of its use as a flux in metallurgical work in assisting refractory minerals to flow. It is a compound of calcium and fluorine (calcium fluoride CaF_2), consisting of calcium 51·28 and fluorine

48·72 per cent.* It has a perfect octahedral cleavage, its lustre is vitreous, and it crystallises in the cubic or tesseral system. It has a specific gravity of 3·1; its hardness (Mohs' scale) being 4. It occurs in massive or amorphous and crystalline forms, twins, druses, and single crystals, and is frequently invested by other minerals such as quartz, siderite, blende, etc. With the blow-pipe, the flame-coloration is fairly good; it decrepitates to a great extent, but finally fuses at 2·5 to 3, with ebullition. In a closed tube fluorine-reactions are well given.† Diathermanous bodies are those which transmit radiant heat readily, and in respect to the diathermancy of fluorspar Prof. H. Adams quotes the following percentage scale by Mr. J. Spencer:—Dry air, 100; rock-salt, 92; fluorspar, 72; Iceland spar, 39; plate-glass, 39; distilled water, 10; alum, 9; and ice, 6.‡

Historical.—The history of ornamental fluorspar dates from pre-historic times to the present day. It is stated by Mr. S. F. Emmons,§ who quotes from Mr. G. F. Kunz,‖ "that the mineral was known to the Indians, is proved by the discovery, in some of the pre-historic mounds of the region, of fluorspar, shaped into ornaments." Then Mr. W. Royse, in his account of the "Blue John" spar-mines at Castleton, Derbyshire, speaks of the hill, in which the mines and caverns of this mineral are found, as being called Tray or Tre cliff, and states that in this district the Romans worked the Odin lead-mine, which was afterwards worked by the Saxons, who gave it the name of Woden, from the Saxon god of that name; and also that it was the Romans who first discovered the "Blue John." We are further told that, in excavating at the ruins of Pompeii, two large "Blue John" vases of excellent workmanship were found, so that, for ornamental purposes, this spar came into use not only 2,000 years ago, but in pre-historic times. The price in 1891 was quoted at between £12 to £800 per ton, according to quality. Fig. 1 is an illustration of vases made from Derbyshire "Blue John."

* *Textbook of Descriptive Mineralogy*, by Mr. Hilary Bauerman, 1884, page 376.

† *Aids in Practical Geology*, by Prof. Grenville A. J. Cole, 1891, page 67.

‡ *Cassell's Engineers' Handbook*, by Prof. Henry Adams, page 255.

§ "Fluorspar-deposits of Southern Illinois," by Mr. S. F. Emmons, *Transactions of the American Institute of Mining Engineers*, 1892, vol. xxi., page 31.

‖ "American Gems and Precious Stones," by Mr. G. F. Kunz, *United States Geological Survey: Mineral Resources of the United States*, 1882, page 497.

Mr. J. H. Cardin also states that "Tradition says that it was in this chamber [the crystal chamber] that the inhabitants took refuge when in fear of the Young Pretender and his adherents, in the year 1745, and either to pass away the time or to frighten any intruders, they carved out from the solid spar a figure in the shape of a lion."*

Colour, etc.—The term "fluorescence" was first applied to a physical property observed in this mineral, namely, that when exposed to light fluorspar becomes fluorescent—a peculiar colour appearance akin to phosphorescence. Fluorspar, when cracked along the cleavage-planes or when possessing edge-fractures, has,

FIG. 1.—VASES MADE FROM DERBYSHIRE "BLUE JOHN."

under certain light, a silvery-white appearance, but one may get all the colours of the spectrum or rainbow—red, orange, yellow, green, blue, indigo, and violet. This colour-picture is one of the prettiest exhibited by this mineral. If the fractures are crossed, a mosaic jumble of rainbow colours is the result. A fracture through the point or solid angle of a coloured cube renders the point from the crack white, the other part retaining its original green or purple tint.

* *Visitors' New Guide to Matlock*, by Mr. J. H. Cardin, 1873, page 51.

This mineral possesses quite a suite of colours. One may have a colourless crystal of fluorspar, then one with a faint purple shade or with all the shades or tints from pinkish to deep violet or blue. Pink or rose-coloured fluorspar is rare, but all shades of purple to deep violet are common in the mineral. Amethystine colouring is seen in specimens from the Sedling lead-mine, Weardale. A hand-specimen of transparent or semi-transparent crystals of this amethystine tint looks rich and beautiful. At White's Level lead-mine, Weardale, nearly all the fluorspar got, in former days, was of a beautiful transparent green and emerald-green. Specimens of pale, muddy, pea-green crystals, in druses or groups, frequently show in the centres of the cubes a curded white appearance, which might be called clouded, or having a cauliflower-like appearance. These crystals are opaque. Pink crystals have been found at Boltsburn mine, Weardale. A beautiful pink variety is found in Switzerland.

The writer has frequently seen green crystals from the Weardale mines, with bevelled edges, that is, showing a face running along all the edges of the cube. White's Level lead-mine, Weardale, sometimes yielded these bevel-edged green cubes, some of which contained liquid-cavities and vapour-bubbles. Mr. H. Bauerman states that "the lead-mines near Liskeard [Cornwall] produce pale-green cubes of considerable size, having the solid angles modified by planes of hexakisoctahedra."* Flesh-red hexakisoctahedrons occur at Münsterthal in Baden.† Mr. F. W. Rudler, under Cornwall and Devon, mentions the four-faced cube, known technically as the tetrakis-hexahedron, which has the edges bevelled, as being known as the *fluoroid*.‡ Mr. Rudler also states that the faces of a cube of fluorspar, instead of being quite plain, may show markings which represent a very low square pyramid, these facets being known as *vicinal* faces.§ The writer has in his possession an amber-coloured cube, found near the Red vein at Stanhope, with square lines or markings running to a central point on one face of the cube.

* *Textbook of Descriptive Mineralogy*, by Mr. Hilary Bauerman, 1884, page 377.

† *A System of Mineralogy*, by Prof. James Dwight Dana, fifth edition, 1872, page 125.

‡ *A Handbook to a Collection of the Minerals of the British Islands, mostly selected from the Ludlam Collection, in the Museum of Practical Geology*, by Mr. F. W. Rudler, 1905, page 86.

§ *Ibid.*

Mr. H. Bauerman refers to a coloured variety, the crystals of which are dark green in the centre and bright blue along the edges, as being characteristic of Weardale.* Wine-yellow or amber-coloured fluorspar sometimes occurs in Weardale, Killhope Head mine having produced amber, bright-blue, and dull pea-green coloured fluorspar. Boltsburn mine, Weardale, a rich present-day lead-mine, belonging to the Weardale Lead-mining Company, Limited, presents, in the "flats" or horizontal deposits of galena, perhaps the most magnificent display of galena and of purple crystalline fluorspar ever seen in the North of England lead-mining field. Cubes of purple spar up to 10 inches on the side are scattered about in various directions in the caverns or lough-holes and workings associated with these galena flats.†

The writer possesses cubes with 3-inch sides of a deep and rich violet-blue or plum-blue colour, which are practically opaque. In some of the specimens the colour is ribbon-banded, as in chalcedony. In others, it would appear as though there were an inner cube of purple encased in a colourless deposit one-sixteenth of an inch deep, yet there is but one solid cube, the appearance being due to colour in the first deposit and a later enveloping deposit of colourless fluorspar.

Cause of Colour.—Mr. H. Bauerman states that "the colour of fluor is probably due to some hydrocarbon compound, as most of the dark-coloured varieties are bleached, or turn to a pale yellow, when heated up to the phosphorescing point. Bubbles of a hydrocarbon gas have been found enclosed in hollows in the crystals."‡ Mr. G. Wyrouboff agrees with these conclusions.§ Experimenting later on some of the American deposits of fluorite, Mr. Wyrouboff considered that the colour-variation was due to hydrocarbons present in the mineral rather than to metallic oxides, and found that specimens with the strongest odour, when broken, had the deepest colour. In the course of

* *Textbook of Descriptive Mineralogy*, by Mr. Hilary Bauerman, 1884, page 377.

† "The Boltsburn Flats: Their Interest to the Student of Nature," by Mr. Stephen Watson, *Transactions of the Weardale Naturalists' Field Club*, 1904, vol. i., page 146.

‡ *Textbook of Descriptive Mineralogy*, by Mr. Hilary Bauerman, 1884, page 378.

§ "Sur les Substances colorantes des Fluorines," by Mr. G. Wyrouboff, *Bulletin mensuel de la Société Chimique de Paris*, second series, 1866, vol. v., page 334.

his experiment, he tested fluorite of different colours, including violet, dichroic, yellow, green, blue and white varieties, and found that all specimens that possessed odour contained hydrocarbons, whilst colourless fluorite from Cumberland had no odour and contained no hydrocarbons. Considering these experiments, and the fact that the decolourisation of the mineral was attained by moderate heating, Mr. W. S. Tangier Smith agrees with Mr. Wyrouboff's conclusions.*

Referring to Mr. Wyrouboff on the colour of fluorspar, Mr. F. W. Rudler observes—

"More recently the studies of K. v. Kraatz-Koschlau and Lothar Wöhler have supported Wyrouboff's views.† They found in a violet fluorspar from Weardale 0·01 per cent. of carbon and 0·008 of hydrogen, in blue and green fluor from Cumberland 0·009 of carbon and 0·002 of hydrogen, and in yellow fluor from Durham [Weardale] 0·007 of carbon and 0·0025 of hydrogen: whilst the colourless fluor was free from either of these elements." ‡

Hydrocarbons are compounds of carbon and hydrogen, being gaseous when hydrogen predominates, liquid with less hydrogen, and solid when carbon predominates. Hydrocarbon compounds appear to be plentiful in the Derbyshire lead-mines, at Windy Knoll quarry, near Castleton, and at other places in the neighbourhood.

Perhaps Weardale and Allendale stand at the head in the North of England for beautiful fluorspar, the brilliant colour and symmetry of form of its fluorspar being the trade-mark and pride of Weardale. This was noticed by the late Mr. Thomas Sopwith, who stated that—

"The beautiful spars which adorn the mantel-pieces of many houses in the northern towns are often designated by the general name of Alston Moor spars. But only a very small proportion of them are the product of veins in this manor, by far the most beautiful and abundant of these specimens being found in the mines of Weardale and Allendale. Fluorspar of different colours, quartz, and the ore of zinc, blende and calamine, or 'Black Jack,' as it is locally termed, are the prevailing spars of Alston Moor." §

* "The Lead, Zinc, and Fluorspar-deposits of Western Kentucky," by Messrs. E. O. Ulrich and W. S. Tangier Smith, *United States Geological Survey: Professional Papers*, No. 36, 1905, page 125.

† "Die natürlichen Färbungen der Mineralien," by Messrs. K. v. Kraatz-Koschlau and Lothar Wöhler, *Min. Mitt.*, 1899, vol. xviii., pages 304 and 447.

‡ *A Handbook to a Collection of the Minerals of the British Islands, mostly selected from the Ludlam Collection, in the Museum of Practical Geology*, by Mr. F. W. Rudler, 1905, page 174.

§ *An Account of the Mining Districts of Alston Moor, Weardale, and Teesdale*, by Mr. T. Sopwith, 1833, page 110.

Dealing with fluorite, as represented in the Museum of Practical Geology, Mr. F. W. Rudler points out that some of the finest known crystals of fluorite have been obtained from the northern lead-mining districts, especially from the mines of Weardale, county Durham. The large series of representative specimens exhibited in the museum include, we are told, many crystals which rival the fluors from Derbyshire, Cornwall, and Devon. These northern fluors are generally crystallised in simple cubes which, in most cases, are boldly and symmetrically developed. A cube of Weardale purple fluorspar is mentioned as being extended along one axis, so that the face represents a long rectangle parallelopipedon.* For its fluorspar, then, Weardale can hold its own.

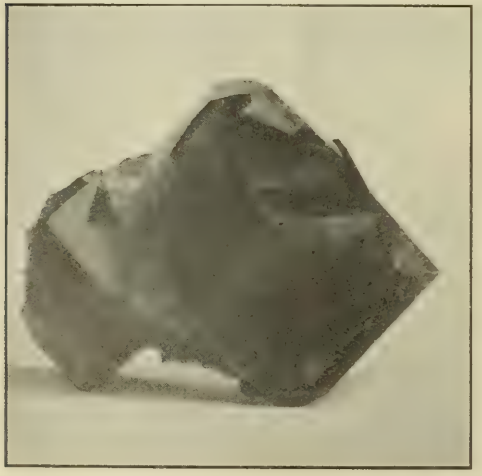


Fig. 2. Twin-cube of Purple Fluorspar, with Liquid Enclosure.

Drop Diamond (fig. 2.) — Single cubes of Weardale fluorspar are sometimes the special product of some mine or part of a mine. Half-a-century ago, White's Level lead-mine had a clay-drift or cavity, partly filled with a very fine dark clay, called "dowk." This drift was noted for its small single green cubes found amongst the clay. The so-called "drift" was evidently a natural cavern, and probably the cubes had fallen off the sides into the clay. These single cubes were locally called diamonds, and it was not uncommon to find some of them with a minute cavity enclosing water, or some hydrocarbon, or liquid carbonic acid. Locally, it was considered that the cube contained a drop of water with an air-bubble, hence the term "drop diamond." The writer is in possession of a fine twin cube of purple fluorspar

* *A Handbook to a Collection of the Minerals of the British Islands, mostly selected from the Ludlam Collection, in the Museum of Practical Geology*, by Mr. F. W. Rudler, 1905, page 174.

(fig. 2), in which is a liquid cavity with an air-bubble, having, like a spirit-level, a run of half-an-inch. Such bubbles vary in size from those invisible to the naked eye to the size of a buck-shot. In the study of liquid cavities with air-bubbles found in quartz and other rocks, experts state that, from this character, an estimate may be made as to the pressure in thousands of feet under which such rocks, granite and others, have consolidated, and as to the corresponding temperature.

Fluorspar Prisms.—A piece of fluorspar broken off a cube along the cleavage planes was found, by the writer, to be of prism-shape, and on being placed over a small object, two objects appeared; on raising the prism, the distance between the objects widened, according to the distance to which the prism was raised. The writer also has had a piece of light purple fluorspar cut into the shape of a prism, and polished by an expert, its refraction being perfect.

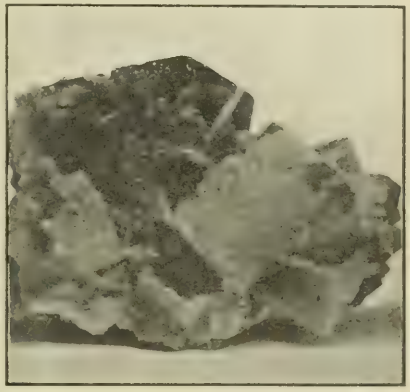


Fig. 3.—Invested Fluorspar.

Minerals Investing Minerals (fig. 3).—Fluorspar plays an important part in this interesting phenomenon of one mineral investing another. If the investing mineral is siderite, the specimen is said to be "rusted," and when invested with small clear crystals of quartz (rock-crystal), it is locally said to be "frosted." More than fifty years ago, Sir Warington W. Smyth, when writing on the iron-ores of Weardale, called attention to the many cases of incrustations on the previously-formed crystals of fluorspar and galena, and, further, to the striking manner in which it was often found to coat only particular crystallographic faces.*

* "Iron-ores of the Northern and North-midland Counties of England (Cumberland, Durham, Northumberland, Lancashire, Yorkshire, and Derbyshire)," by Mr. Warington W. Smyth, *Memoirs of the Geological Survey of Great Britain and of the Museum of Practical Geology: The Iron-ores of Great Britain*, 1856, page 19.

In the *Handbook to the Museum of Practical Geology*, it is pointed out that in many of the specimens crystals of a later-formed mineral have been deposited on particular faces only of the pre-existing mineral, the laws determining this selective action being in many cases far from obvious.

The writer has noticed that specimens of fluor, quartz, and other spars from the Weardale lead-mines are very frequently invested on faces of the pre-existing crystals in one direction only, whilst the faces in the opposite direction represent the natural faces of the older mineral which is invested. Fluorspar, quartz, galena, calcite, iron-pyrites, siderite, and zinc-blende are the minerals found investing each other. Fluorspar is frequently found invested with quartz and siderite, and groups of quartz-crystals are often incrusted with siderite. All this investment seems to follow one law: that of incrusting one side only of the crystals receiving the investing mineral; whilst the pre-existing minerals show comparatively large crystals, the secondary or investing mineral consists of small crystals. A description of a few specimens in the writer's possession may be of interest. A group of quartz-crystals is invested, on one side only, with a snow-like dust, which, on examination, proves to be a mass of clear white crystals of fluorspar. It may be mentioned that the drusy quartz-crystals which are thus invested had previously invested fluorspar-crystals, so that we have fluorspar invested with quartz, which mineral again is invested with snow-like fluorspar crystals, evidently a second secondary, or, rather, a tertiary deposit. In another specimen, a cube of fluorspar, with sides of $1\frac{1}{2}$ inches, has been invested with small quartz-crystals; then the cube started to grow again, and the investing quartz was overlain by fluorspar, $\frac{1}{8}$ inch thick, and again one side has been further invested with brown velvety siderite. In this case, we have a cube of fluorspar invested with small quartz-crystals, which in turn have been invested with fluorspar, which finally is invested with carbonate of iron. A third specimen consists of a cluster of dull-green cubes, 3 inches long, of fluorspar, with white clouded centres, the cubes being invested on one side only with siderite.

It is not uncommon to see small fluorspar cubes of about an inch on the side being sparsely invested on one or two sides with small pyramidal transparent rock-crystals, which look like

cut and polished diamonds. The question may be asked: why this one-sided investment?

Fluorspar Enveloped in Chalcedony.—The writer has a section of a hand-specimen of quartz, which he has had polished, and this shows in the centre two greenish fluorspar cubes, about $\frac{5}{8}$ inch across. These cubes are invested with banded white-and-brown wavy chalcedony, which follow the squares of the fluorspar. Finally the banded chalcedony is covered with quartz, about $\frac{1}{2}$ inch thick.

Crystals within Crystals.—Specimens of this class are most interesting, exhibiting as they do the crystal of one mineral embedded in the solid crystal of another mineral. Nicolaus Steno* sets forth (1) that rock-crystal has once been liquid, as is shown by the way in which it encloses other bodies; and (2) rock-crystal may increase in size, as is proved by the fact that sometimes stages in the growth are indicated by the positions of the enclosures.†

Specimens in the writer's possession fully support the above statement, fluorspar being the enclosing and rock-crystal the enclosed mineral, and *vice versa*. In this interesting phase in the life-history of fluorspar may be observed some most wonderful phenomena. In one specimen (a cube of fluorspar an inch or so on the side), the purple stage had evidently been suspended and a number of small quartz-crystals had formed or settled down on the upper face of the cube. Then the fluorspar-crystal had commenced to grow again, and, without being influenced in the slightest degree by the quartz-crystals, put on a band of pure colourless fluorspar, in which the rock-crystals were embedded. Another specimen, consisting of a drusy group of milky-white pyramids of quartz, has embedded in the pyramids small cubes of galena and also small cubes of pale-pink fluorspar—these two minerals, in some cases, being very near each other. Another group of quartz-pyramids have embedded in them small blackish specks of specular iron. In a third specimen (a cube of clear purple fluorspar) are embedded several perfect specimens of rock-crystals having the double pyramid.

* *De Solido intra Solidum naturaliter contento*, by Nicolaus Steno, Florence, 1669; English translation, 1671.

† *British Museum Mineral Department: Introduction to the Study of Minerals, with a Guide to the Mineral Gallery*, by Mr. L. Fletcher, 1897, page 24.

Weardale Fluorspar.—The Burtreeford fault has, apparently, had considerable influence in regulating the mineral-deposits in the veins of Weardale and the surrounding country. This dislocation crosses Weardale from the north at the village of Burtreeford, near Cowshill, and continuing in a southerly direction it runs through Burnhope into Teesdale. It has a downthrow to the east of 80 fathoms, which appears to have placed the rocks at an horizon favourable to the deposition of fluorspar. Westgarth Forster pointed out that the metalliferous veins east of this great fault were generally of a softer nature than those on the west side, and contained generally, as a matrix, calcareous spar and fluorspar, as at Allenheads and in the extensive mines in Weardale and Derwent, all of which are on the east side of the fault. The lead-mines at Coal Cleugh, Alston Moor, and Killhope, and also the upper Teesdale mines, are all on the west side of the fault, the metalliferous veins being generally of a harder nature, and the accompanying minerals contain a good deal of zinc-blende and rider and also cauk or barytes.* Mining operations have amply proved these statements to be correct. The same writer also pointed out that the once celebrated Cross Fell lead-mine and the veins east of Cross Fell generally contained "amorphous" fluorspar and galena, whilst the veins on the west side of the mountain were filled with sulphate of barytes and galena.†

A writer on the Yorkshire mines states that fluorspar is not common in the county, being only sparingly found, while it has been stated that fluorite occurs in Swaledale and Teesdale, but not in sufficient quantity to repay working: probably, however, some of the lead-mines would pay for raising fluorspar as a bye-product. No attempt has ever been made to raise fluorspar in Teesdale, but a miner had seen some very sparry "bouse" come out of Coldberry mine, and there are waste-heaps containing fluorspar at Lodge Syke mine, and also a sparry vein at Bleagill mine, which has yielded lead-ore.

The late J. G. Goodchild pointed out—

"That fluorspar occurs chiefly in the lead-veins traversing the Carboniferous rocks, but it does not occur in any great quantities in the non-calcareous rocks.

* *A Treatise on a Section of the Strata from Newcastle-upon-Tyne to the Mountain of Cross Fell, in Cumberland; with Remarks on Mineral Veins in General*, by Mr. Westgarth Forster, second edition, 1821, page 269.

† *Ibid.*, page 276.

In the lead-mining districts, it occurs perhaps in nearly all the veins of one part, while in the veins of an adjoining area, traversing precisely the same rocks, and, to all appearance, produced under precisely similar conditions, it is frequently conspicuous by its absence."*

This is supported by the previously-mentioned fact that Weardale and Allenheads veins, on the east side of the Burtreeford fault, are the most productive of fluorspar in the North of England lead-mining districts. Nearly all the metalliferous veins in the Lake District are quartz-veins.

Origin of Fluorspar in Veins.—Fluorine was unknown in the free state until some twenty years ago, when it was "obtained as a colourless gas which decomposes water, liberating oxygen and combining with hydrogen to form hydrofluoric acid."† Prof. Lewes also states that—

"The four elements fluorine, chlorine, bromine, and iodine, exhibit a gradual difference in properties and in their power of combining with other elements, fluorine having the greatest affinity for metals and iodine the least; whilst the solubility of the compound formed in combining with oxygen is in reverse order, iodine forming the strongest compound: fluorine is the only element which does not combine with oxygen." ‡

Considering that fluorine has a great affinity for metals, and that it does not combine with oxygen, and, further, that silicon is not acted upon by any acid except hydrofluoric, with which it forms silicon fluoride, it would not be surprising to find that this element played some active part in the deep-seated rocks in respect to the change of mineral matter. Mr. J. H. Collins calculated that the tourmaline-bearing rocks of the West of England contained something like 2,480,000 tons of fluorine for each yard in depth.§

It has been stated, with reference to the origin of clay, that "the kaolinisation of felspar may be effected by ordinary weathering, yet in most cases the alteration has probably been brought about by subterranean rather than by superficial agencies. It is notable that in Cornwall, where the decomposition of

* "Contributions towards a List of the Minerals occurring in Cumberland and Westmoreland," by Mr. J. G. Goodchild, *Transactions of the Cumberland and Westmoreland Association of Literature and Science*, 1882, part vii., page 114.

† *Service Chemistry*, by Professor Vivian B. Lewes, second edition, 1895, page 353.

‡ *Ibid.*

§ "On the Origin and Development of Ore-deposits in the West of England," by Mr. J. H. Collins, *Journal of the Royal Institution of Cornwall*, 1893, vol. xi., page 371.

the granite has proceeded to great depths, the kaolin is usually accompanied by minerals containing compounds of fluorine and boron; and a similar association has been observed in other china-clay districts. The characteristic associates of the altered felspars in the clay-yielding granites are such minerals as tourmaline, lepidolite, topaz, apatite, and fluorspar."*

Other fluorine minerals are fluellite, a hydrated fluoride of aluminium; cryolite, a double fluoride of aluminium and sodium, from Greenland; tourmaline, a boro-silicate, containing about 2 per cent. of fluorine; and apatite, a phosphate of calcium, associated with either a chloride or a fluoride of the same metal, known as chlor-apatite and fluor-apatite respectively.

As far back as 1824, Mr. Leopold von Buch suggested that certain kaolins had probably resulted from the action of compounds containing fluorine, rising from deep-seated subterranean sources, and attacking felspathic rocks.† And further, these views were modified and extended by Mr. A. Daubrée, who supported them by ingenious experimental evidence.‡ It is worth noting, too, that Mr. J. H. Collins has effected the kaolinisation of felspar by means of hydrofluoric acid.§

Metasomatism.—Several American writers, including Messrs. H. Foster Bain, S. F. Emmons, E. O. Hovey, W. S. Tangier Smith, and others, have studied the formation of fluorspar-veins. The general conclusion appears to be that the original fissures have been filled with the mineral, whilst a good deal of replacement has taken place through metasomatic action.

Writing on fluorspar-deposits, Mr. S. F. Emmons states that—

"A considerable proportion of the deposit, especially in the hanging-wall portion of the vein, has undoubtedly been formed by replacement or substitution. The fœtid character of some of the spar, which it undoubtedly inherits from the replaced limestone, the residual bituminous matter found in the vein-material, and in one case a fossil, as mentioned with regard to the Kentucky deposits by Norwood, are proofs of this, in addition to the already sufficient banded arrangement of the vein-material and replaced portions of dragged-in country rock."‖

* *Handbook to the Collection of British Pottery and Porcelain in the Museum of Practical Geology*, 1893, page 5.

† "Ueber den Thüringer Wald," by Mr. Leopold von Buch, *Min. Taschenbuch*, 1824, page 437.

‡ *Etudes synthétiques de Géologie expérimentale*, by Mr. A. Daubrée, 1879, page 64.

§ "On the Nature and Origin of Clays: The Composition of Kaolinite," by Mr. J. H. Collins. *The Mineralogical Magazine and Journal of the Mineralogical Society*, 1887, vol. xi., page 205.

‖ "Fluorspar-deposits of Southern Illinois," by Mr. S. F. Emmons, *Transactions of the American Institute of Mining Engineers*, 1892, vol. xxi., page 51.

This writer is also of opinion that the known facts "point to the derivation of the fluorspar from the mass of the surrounding limestone."*

Another writer, of later date, Mr. W. S. Tangier Smith, referring to metasomatic replacement, says that "the question arises what proportion of the massive fluorite of the fissure veins, if any, has been formed by the replacement of the limestone composing the walls of the original fissure?"† He points out that "there is little evidence bearing on this point, and that of a negative character. From the facts determined, however, the writer [Mr. W. S. Tangier Smith] is led to the conclusion that the veins have been largely formed by fissure-filling, although in some cases it is probable that there has been more or less replacement of the country rock by fluorite."‡ This writer further mentions that at the Columbia mine "a part of the limestone had been replaced mainly by sphalerite, the rest mainly by fine-grained fluorite, associated with very little sphalerite. The fluorite in thin section still shows outlines of some of the microscopic fossils originally contained in the limestone."§

Referring to the fluorite-deposits in Southern Illinois, Mr. H. Foster Bain says that—

"In general the great width of the vein is probably due to the facility with which the less soluble calcium fluorite is formed in the place of calcium carbonate whenever fluorine is available. This has resulted in extensive replacement of the limestone wall through metasomatic processes . . . . . This process is not believed, however, to have operated to the exclusion of normal vein-filling in open cavities, since, for example, in the McClellan mine . . . . there is a considerable body of clear fluorspar where both walls are sandstone and where, accordingly, there is little opportunity for simple replacement. . . . . The co-operation of the two processes of open fissure-filling and metasomatism is, as Mr. Lindgren has shown, normal and quite in accord with what should be expected."‖

Mr. Bain further points out that—

"There are two broadly contrasted methods by which the present orebodies may have been concentrated. The first is by the action of the normal

* "Fluorspar-deposits of Southern Illinois," by Mr. S. F. Emmons, *Transactions of the American Institute of Mining Engineers*, 1892, vol. xxi., page 52.

† "The Lead, Zinc, and Fluorspar-deposits of Western Kentucky," by Messrs. E. O. Ulrich and W. S. Tangier Smith, *United States Geological Survey: Professional Papers*, No. 36, 1905, page 142.

‡ *Ibid.* § *Ibid.*, page 139.

‖ "The Fluorspar-deposits of Southern Illinois," by Mr. H. Foster Bain, *United States Geological Survey: Bulletins*, No. 255, 1905, page 41.

meteoric waters . . . . which may . . . . have gathered the disseminated material from the country rocks into the veins. The second is by the action of heated waters, either originally meteoric or derived from the intruded igneous rock, or in part from each source. It is believed that the evidence points to heated waters having been the agency by which the ores were segregated and that they obtained an essential portion of their load from a large mass of lower-lying intruded rock, of which the dikes are the offshoots."*

After considering "that the ore-bodies show no sign of secondary enrichment, and apparently the surface-waters now in the region can only operate to destroy rather than re-form the ore-bodies,"† Mr. Bain refers to fluorite as being relatively insoluble in cold water as compared with limestone, and states that crystals of fluorspar in druses are relatively rare: he concludes that "It is difficult to believe, therefore, that such waters have gathered minutely disseminated quantities of fluorite from the surrounding limestone and formed the veins as they now occur."‡

Mr. Bain also points out that—

"Fluorine has commonly been observed in connection with volcanic outbursts, and fluorite is one of the most common minerals connected with volcanic rocks. At Cripple Creek, Colorado, and many other western camps it is abundant in intrusive and extrusive rocks of Tertiary age. So far, then, the igneous rocks form a very probable source of the fluorine, but the evidence that the material did actually come from them is weak."§

In the *Memoirs of the Geological Survey of England and Wales*, reference is made to one of the so-called veins, which is stated to consist of very irregular, flattened pipes, running for a while almost horizontally, and then bending up, etc., and that at a place where a certain section was taken, where the vein was nearly flat—

"Its upper and under surfaces are lined by coatings of blue fluor, and the space between these is filled up by a mixture of reddish-brown clay, yellow, crystallised fluorspar, and nodular barytes. In this are scattered here and there concretions of the 'Blue John,' arranged in concentric layers of different tints, and radiated. Some of these concretions are coated with clay. Nodules of 'Blue John' are also found in the solid limestone."‖

* "The Fluorspar-deposits of Southern Illinois," by Mr. H. Foster Bain, *United States Geological Survey: Bulletins*, No. 255, 1905, page 66.

† *Ibid.* ‡ *Ibid.* § *Ibid.*, page 65.

‖ *Memoirs of the Geological Survey of England and Wales: The Geology of the Carboniferous Limestone, Yoredale Rocks, and Millstone Grit of North Derbyshire*, by Messrs. A. H. Green, C. Le Neve Foster, and J. R. Dakyns, second edition, with additions by Messrs. A. H. Green and Aubrey Strahan, 1887, page 162.

Such is one of the fluor-flats of North Derbyshire. The metalliferous veins in the Weardale, Allendale, and Alston districts are nearly vertical, but have, as a rule, a hade to one side; there are also flat or horizontal deposits, the matrix, especially in Weardale and Allendale, being fluorspar. There is one exception in Weardale, namely, the vein running eastward from the Billing Hills, this being a quartz-vein. Fluorspar-veins below the weathering-belt, and sealed up in the solid rock, would be little affected from above, whilst veins above the weathering-belt would be subject to weathering and decomposition, and secondary deposits would take place, but relatively to a small degree. Cracks and fissures are the natural channels for vein-filling, and is it not as easy to say that country rock might be enriched from the veins as that veins were enriched from the country rock? Clearly, the metasomatic action which converted the limestone into ironstone is evidence of rock enrichment from the metalliferous vein. Cavities in limestone in connection with such veins above the weathering-belt get filled with minerals in a crystalline form whilst cavities in limestone not near mineral veins are more likely to be filled with calcite or clay. The writer has seen large pieces of cleavage-calcite taken from cavities in the Great Limestone at Stanhope where there are no metalliferous veins in close proximity.

Dr. Edmund Otis Hovey points out that "a peculiarity of the Kentucky-Illinois district is the association of basic igneous dikes with the veins of fluorspar."* Mr. Bain refers to the significant fact that fluorite is entirely absent in Northern Illinois but occurs in quantity in the Southern Illinois district.

No doubt metasomatic action plays no inconsiderable part in the formation or, more correctly, the alteration of rocks and minerals. Mr. J. D. Kendall, referring to the original iron-ores of Alston Moor and Weardale as being siderite, from which limonite was produced by alteration, states that it (siderite) was formed by replacement of the limestone by solutions of iron, connected with volcanic agency.†

Referring to the hæmatite-deposits of Cumberland, Prof. Henry Louis is of opinion that Mr. Kendall's explanation of the

* "Fluorspar," by Dr. Edmund Otis Hovey, *United States Geological Survey: Mineral Resources of the United States*, 1905, page 1100.

† *The Iron-ores of Great Britain and Ireland*, by Mr. J. D. Kendall, 1893, page 327.

origin of these ores is probably the correct one, that is, he considers them to have been formed by metasomatic replacement of the limestone by solutions of iron.*

Early Mention of Fluorspar in Weardale.—As early as the year 1666, one at least of the Weardale mines was called "Spar Grove," owing no doubt to the abundance of fluorspar. During all the years of lead-mining in the dale, going back at least to the time of King Stephen, fluorspar, in thousands of tons, has been deposited generally in rivers and streams, and being soft would be ground into fine sand. The crystalline forms with all their beautiful symmetry and colour have always been of value for ornamental purposes; whilst the "amorphous" or vein-spar has only recently been recognized as a valuable commercial product.

It is interesting to find that Westgarth Forster, in 1821, gives a list of thirty-six lead-mines working, or having been worked, in Weardale, no less than twenty-five of which are stated to have fluorspar associated with the lead-ore.† Fluorspar was of no commercial value at that time; but the fact was mentioned, owing to this "vein" or "vein-stuff" being prominently associated with galena. At the present day, when fluorspar has a market value, with an improving trade, the information may be of interest to merchants and miners.

Analyses of Weardale Fluorspar.—Through the courtesy of Mr. Errington Thompson, chief agent of the Weardale Lead-mining Company, Limited, the writer is able to increase the value of this paper by giving the following analyses of fluorspar from three representative Weardale mines, belonging to the company. The analysis marked "Groverake" represents a mine in Rookhope, a sub-northern valley of Weardale: Stanhopeburn, a mine worked in the Red vein, is near Stanhope; and Sedling mine, worked in a vein of that name, is situated near Cowshill. All these mines are on the northern side of the river Wear, the most productive side of the valley.

* *A Treatise on Ore-deposits*, by J. Arthur Phillips, second edition, rewritten and enlarged by Prof. Henry Louis, 1896, page 175.

† *A Treatise on a Section of the Strata from Newcastle-upon-Tyne to the Mountain of Cross Fell, in Cumberland; with Remarks on Mineral Veins in General*," by Westgarth Forster, second edition, 1821, page 304.

	Groverake Mine: Lump Spar. Per Cent.	Stanhopeburn Mine: Lump Spar. Per Cent.	Sedling Mine: Lump Spar. Per Cent.	Sedling Mine: Smalls. Per Cent.
Silica	traces	3·24	4·50	2·40
Calcium fluoride ...	93·68	96·06	91·51	93·89
Calcium chloride ...	traces	—	—	—
Barium fluoride	2·42	—	—	—
Barium sulphate ...	0·42	—	—	—
Oxides of iron	0·21	0·24	0·23	1·00
Alumina	0·29	0·36	0·12	0·35
Magnesia	0·23	traces	traces	traces
Phosphoric acid .. ... (=Phosphorus)	0·13 (0·056)	0·052 (0·023)	0·064 (0·028)	0·064 (0·028)
Organic matter	traces	—	*nil*	traces
Combined water	2·56	traces	0·75	1·05
Moisture	0·09	—	0·15	0·15
Oxide of manganese ...	—	traces	—	—
Sulphide of lead	—	0·086 (=Sulphur, 0·053)	1·85 (=Lead, 1·60)	0·47 (=Lead, 0·41)
Sulphide of zinc	—	0·126 (=Sulphur, 0·053)	0·83 (=Zinc, 0·56)	0·71 (=Zinc, 0·48)
	100·03	100·164	100·004	100·084

II.—Commercial Uses of Fluorspar.

Before referring to the present use of this mineral, as a most valuable flux, it may be interesting to refer to its early use in Weardale, where, at the lead-mines, for hundreds of years, fluorspar was abundantly produced in the process of mining for lead-ore, but only as a waste material. In early days, however, the vein-matrix or gangue of the lead-veins, pea spar-gravel, generally of a lightish grey colour, with a pinkish or faint-blue tinge, or with a purple or greenish tinge, and of a bright appearance, was a favourite material for garden-walks or footpaths, and hundreds of tons were used for this purpose. Spar-gravel was also, and is still, used on the outside walls of houses which are "slab-dashed" with fluorspar, that is, the walls, after being covered with lime, are sprinkled with spar-gravel, which is dashed or thrown on to the walls whilst the lime is yet soft, the particles of gravel sticking to the walls, which then present a covering, or coat, which in the sunshine has a beautiful and glittering effect. Many years ago, the writer knew a dwelling-house at Westgate, Weardale, called "Sparry Hall," the walls of which were treated in this manner. Sometimes the gravel is subjected to a general cement-wash, which gives the walls a grey and rough appearance.

Fluorspar in small quantities was dispatched from Weardale for use as a flux so early as the year 1847, and large quantities were, twenty years ago, sent to Scotland and America. Fig. 4 shows a heap of the mineral lying at Wearhead station.

Optical Properties.—It has been stated that transparent fluorite was sometimes used, on account of its optical properties, in the manufacture of microscope objectives and other refined optical instruments, but the writer was quite recently informed by an optician that he did not think fluorspar was ever used for this purpose.

FIG. 4.—FLUORSPAR (FROM THE SEDLING MINE) AT WEARHEAD STATION.

Mr. F. W. Rudler, however, referring to fluorspar destitute of colour, states that " the dispersive power and refractive power of fluor render the pellucid colourless mineral of value for the construction of objectives for microscopes, as introduced by Prof. Abbe. A variety from Switzerland has been applied to this purpose. The lenses of fluor are used in conjunction with lenses of Jena glass, so as to produce an improved kind of achromatic objective which is termed ' apochromatic.' "*

* *A Handbook to a Collection of the Minerals of the British Islands, mostly selected from the Ludlam Collection, in the Museum of Practical Geology*, by Mr. F. W. Rudler, 1905, page 87 ; and *Jena Glass*, by Dr. H. Hovestadt, translated and edited by Prof. J. D. Everett and Mrs. Alice Everett, 1902, page 88.

Fluorspar as a Flux.—We are informed by Prof. Vivian B. Lewes that fluorspar has been used, from the earliest ages, as a flux in metallurgical processes.* It has been used, as is well known, in small quantities for the production of hydrofluoric acid for etching glass; it was also formerly employed in a secret process as a cleansing agent for castings, but is now being used as a valuable and general means for this purpose.

It is the high-grade fluorspar, namely, the pure white or pale blue, that is used for enamelling purposes, and in the manufacture of agate ware and opalescent or milky glass. It has also been used in the smelting of tin, copper, nickel, and lead, and for various other purposes.

Fluorspar and the Reduction of Lead.—Mr. W. S. Tangier Smith states that "fluorspar is used chiefly as a flux in the manufacture of steel and pig-iron, and to a minor extent in the reduction of lead."†

The fact that the mineral was used in England as a flux for the reduction of lead so long ago as 1730 is of interest, and, no doubt, it was employed long before that date. Dealing with mining operations in Derbyshire at that date, mention is made of a simple bloomery for the reduction of lead, as follows:—

"The furnace, which I saw near Worksworth, was very rude and simple, consisting only of some large rough stones, placed in such a manner as to form a square cavity, into which the ore and coals are thrown *stratum super stratum*; two great bellows continually blowing the fire, being moved alternately by water. I saw no other fuel used on this occasion but dried sticks, which they call white coal. . . . . They generally throw in some spar along with the ore, which is thought by imbibing the sulphur to make it flux more easily. They frequently throw in also some cowke (or cinders of pit-coal) because they think it attracts the dross, and so makes an easier separation of it from the lead. When the ore is melted, it runs out at an opening in the bottom part of the front of the furnace, through a small channel made for that purpose, into a cylindrical vessel, out of which it is ladled into the mould. The dross of the ore on smelting is called slag. This slag is afterwards smelted again with cowke only, and the lead obtained from it is called slag-lead."‡

* *Service Chemistry*, by Prof. Vivian B. Lewes, second edition, 1895, page 354.

† "The Lead, Zinc, and Fluorspar-deposits of Western Kentucky," by Messrs. E. O. Ulrich and W. S. Tangier Smith, *United States Geological Survey: Professional Papers*, No. 36, 1905, page 118.

‡ *The Philosophical Transactions* [*of the Royal Society*] (*from the Year 1719, to the Year 1733*) *Abridged and Disposed under General Heads*, by Messrs. John Eames and John Martyn, 1734, vol. vi., part ii., page 193; and *Memoirs of the Geological Survey of England and Wales: The Geology of the Carboniferous Limestone, Yoredale Rocks, and Millstone Grit of North Derbyshire*, by Messrs. A. H. Green, C. Le Neve Foster, and J. R. Dakyns, second edition, with additions by Messrs. A. H. Green and Aubrey Strahan, 1887, page 121.

Dr. R. Watson pays a tribute to fluorspar as a flux when he states that—

"The lead-smelters [Derbyshire] make great use of the cubical spar as a flux for such lead-ores as do not readily melt: it is curious to see its effect; a few shovels full of it, thrown upon a heap of red hot ore, immediately melting down the ore into a liquid, though the longest continuation of the same degree of heat, without the addition of the spar, would not have been sufficient for the purpose."*

Perhaps its use in Derbyshire spread to other mining fields in the North of England. About 1857, or before, Mr. William Bolton, on the recommendation of the late Mr. Bainbridge of Middleton-in-Teesdale, used a little fluorspar in the reduction of lead at Dufton, Westmoreland; and it was thought by the writer's informant that Mr. Bainbridge might have seen it used in Derbyshire for the smelting of lead-ore.

Old smelters in the Allendale district do not know that fluorspar has ever been used for the reduction of lead, and the smelter at the Weardale Lead-mining Company, Limited's, smelting-mills, states that fluorspar acts as a flux in two ways: (1) by combining with silicates, forming fusible compounds, and (2) by reacting on silicates and evolving silicon fluoride. He states that it also forms fusible compounds with sulphates of lime and baryta, and with phosphates of lime; and it should be free from pyrites, blende, and galena. He mentions that in fume-smelting and slag-smelting a little of it acts beneficially, but he has not gained any advantage by its use in ore-smelting, having tried both raw and roasted fluorspar.

Mr. Ernest F. Burchard, a recent writer, points out that—

"Fluorspar has been shown to possess a considerably higher quantitative efficiency as a flux than limestone, especially in smelting refractory ores, but in all metallurgical operations the proportions of the spar that can be used are limited, since its favourable effects do not increase indefinitely as the quantity is increased."†

Fluorspar and the Manufacture of Iron and Steel, etc.—Fluorspar is adapted, perhaps above all other minerals, for dissolving quartz, sulphate of baryta, and such mineral matter as retards the smelting processes in the manufacture of steel and iron;

* *Chemical Essays*, by Dr. R. Watson, seventh edition, 1800, vol. iii., page 216.

† "The Production of Fluorspar and Cryolite in 1906," by Mr. Ernest F. Burchard, *United States Geological Survey: Mineral Resources of the United States*, 1907.

so much so that a forecast might well be made that no mineral in the future will be of more value for the manufacture of steel, iron, and other metals. We find it stated that to metallurgical processes in dealing with refractory ores fluorite is especially adapted, owing to its fluidity in the formation of slag at a low temperature.

Mr. Joseph Hyde Pratt, referring to foundry-work, says, "for this purpose the fluorspar gives a much cleaner iron, and its demand should be almost unlimited as foundrymen become better acquainted with its value for use in their furnaces."*

Mr. Ernest F. Burchard, dealing with this subject, states that

"The three principal classes of consumers of fluorspar are, in order of importance, smelters and metallurgists, makers of opalescent glass and enamelled wares, and chemical manufacturers. The highest grade, American lump No. 1, which runs less than 1 per cent. silica and is colourless or clear-blue in colour, is sold either ground or in lump, for use in the glass, enamelling, and chemical industries, the latter including the manufacture of hydrofluoric acid. The second grade, lump No. 2, is used by blast-furnaces in the production of ferrosilicon and ferromanganese, and in basic open-hearth steel-furnaces to give increased fluidity to the slag and to reduce the contents of phosphorus and sulphur. This grade includes coloured spar and may run as high as 4 per cent. silica, though mostly sold with a 3 per cent. guaranty. The lowest grade, gravel-spar, including all that contains more than 4 per cent. silica, as well as spar mixed with calcite, is used in iron and brass-foundries, where it is of value in making the metal more fluid, in permitting the use of greater quantities of lower grades and scrap, and because it carries phosphorus, sulphur, and other impurities into the slag."†

Mr. F. Julius Fohs tells us that—

"Among the more recent applications of fluorspar to new uses may be mentioned: (*a*) In the reduction of aluminium from bauxite, a purpose for which the demand is likely to increase, at the same time causing a decrease in the importation of cryolite. (*b*) As a flux for gold ores, assisting in decreasing gold losses as in the Cripple Creek district. (*c*) As a bonding for constituents of emery-wheels. (*d*) For carbon electrodes, increasing their lighting efficiency and at the same time decreasing the amount of required current."‡

Mr. Fohs sums up the uses of fluorspar as being "dependent on its chemical composition, fluxing properties, phosphorescence upon heating, optical and pseudogem properties."§

Fluorspar is also used as a constituent in Portland cement.

* "Fluorspar and Cryolite," by Mr. Joseph Hyde Pratt, *United States Geological Survey: Mineral Resources of the United States*, 1904, page 1032.

† "The Production of Fluorspar and Cryolite in 1906," by Mr. Ernest F. Burchard, *United States Geological Survey: Mineral Resources of the United States*, 1907.

‡ "Fluorspar," by Mr. F. Julius Fohs, *The Engineering and Mining Journal* [New York], 1906, vol. lxxxi., page 46.

§ *Ibid.*

III.—Weardale Fluorspar.

Weardale Metalliferous Veins.—The mineral veins in Weardale, from a mineralogical point of view, may be divided into three classes, especially in considering fluorspar as a matrix:—(1) quartz-veins, (2) veins east of the Burtreeford fault, and (3) veins where fluorspar is not so prominent, namely, west of the Burtreeford fault. All these veins may carry lead-ore and rider or ironstone, but the principal point is to show where fluorite predominates.

(1) *Quartz-veins.*—It may be interesting to consider first the exceptional vein which runs from the Billing Hills eastward over Catterick and down to Bollihope burn, which it crosses at Bishopley Crags, showing two ribs of quartz standing out above the ordinary level of the water-bed. This vein is probably an extension or a string from the Great Sulphur vein of Alston Moor. As the Slitt vein crosses the Wear from the north side at Cammock Eales to Ludwell Wood, the quartz-vein is considered to be an extension, but Westgarth Forster favoured the view that the Catterick or Billing vein was connected with the great "backbone of England" as at Alston.* Between Billing Shields and Ludwell farms may be seen large pieces of quartz-vein matrix which have been used for building and coping the walls. In Stanhope and Frosterley, quantities of this quartz-vein matrix may be seen in borders and rockeries in front of the houses, and blocks of this quartz have also been freely used as rockeries at Horsley Hall. The writer has a large solid piece of this quartz, about 15 inches across and about 4 inches thick. Curiously enough, this specimen opens out a question in mineralogy, the under-side of the specimen representing a pseudomorph, or more correctly, an epimorph after fluorspar, and the white undersurface a beautiful mould of intermixed and crossed squares, which evidently represent decomposed fluorspar. The agents of the Weardale Lead-mining Company, Limited, have some excellent examples of pseudomorphs after fluorspar, some of the shells of the investing mineral having pieces of purple fluorspar still *in situ*, whilst around it are only the moulds of the fluorspar. Mr. William Wallace mentions that, at the Nenthead mines,

* "*A Treatise on a Section of the Strata from Newcastle-upon-Tyne to the Mountain of Cross Fell, in Cumberland; with Remarks on Mineral Veins in General,* by Westgarth Forster, second edition, 1821, page 268.

fluorspar is somewhat rare, but that it must have been at one time very common, as it has left its traces as pseudomorphs in quartz after fluorspar.*

(2) *Veins East of the Burtreeford Fault.*—This district covers the parish of Stanhope, less the heather moorlands west of the Burtreeford fault, as Killhope, Wellhope, and Burnhope. This district is by far the most important, as it produces the whole of the commercial fluorite now being sent from Weardale. Through the kindness of Mr. Errington Thompson, chief agent of the Weardale Lead-mining Company, Limited, the writer has received from Mr. S. Walton, sub-agent, a list of the veins in this district, with their mineral contents, as follows:—

(*a*) *South-east Running Veins.*—Red vein: A strong master vein, 10 to 30 feet in width, running from Allenheads in the west to beyond Stanhope in the east; matrix, generally fluorspar, in some places rider (iron-ore), with large deposits of rider on the side of the fluorspar in the flats at Stanhopeburn mine. The vein also carries a large deposit of iron-ore in Rookhope.

Sedling vein: A strong vein, 8 to 15 feet in width; matrix, fluorspar of good quality; other minerals present are galena, arsenical pyrites, quartz, etc.

Slitt vein: A strong master vein, 10 to 20 feet in width, running into the Burtreeford fault westward and beyond Harehope gill to the east; matrix, generally fluorspar; has been very productive of lead-ore at Elmford, and at the Slitt mine, where it was worked through the Whin Sill.

(*b*) *East-north-east Running Veins.*—Green Cleugh vein: 4 to 6 feet in width; matrix, fluorspar, with lead-ore and also quartz.

Groverake vein: 10 to 20 feet in width; matrix, fluorspar, with lead-ore and, in places, copper pyrites.

Wolf Cleugh vein: 4 to 10 feet in width; matrix, very white fluorspar, with lead-ore, and also carbonate of iron and arsenical pyrites.

Rispey vein: 3 to 4 feet in width; matrix, fluorspar, with lead-ore and carbonate of iron.

Boltsburn vein: 4 to 6 feet in width; matrix, fluorspar, with lead-ore; large flats on both sides of the vein in the Great Lime-

* *The Laws which Regulate the Deposition of Lead-ore in Veins*, by Mr. William Wallace, 1861, page 143.

stone, with large formation of fluorspar crystals in loughs or small cavities; colour, various shades of mauve, violet, blue, and purple; loose blocks or cubes, the residuum of decomposition; calcite in form of stalagmites; carbonate of iron coating galena; quartz, blende, iron pyrites.

Thorny Brow vein: 3 to 4 feet in width; matrix, fluorspar, with lead-ore; formerly productive of lead-ore.

Brandon Walls vein: 3 to 4 feet in width; matrix, fluorspar, with lead-ore.

Scar Syke vein: Matrix, fluorspar, with lead-ore.

Middlehope Shield vein: Matrix, fluorspar, with lead-ore, with fluorspar in druses and single cubes of a beautiful green.

Heights vein: Matrix, fluorspar, with lead-ore, and fine green fluorite in the flats.

Breckon Syke vein: 6 to 12 feet in width; matrix, fluorspar, with lead-ore. This vein runs into Allendale, where it is known as Henry's vein.

Burtree Pasture vein: 6 to 12 feet feet in width; matrix, fluorspar, with lead-ore; level, 2½ miles long, with a 200-fathom vertical air-shaft, from the Whin-sill to the Grindstone-sill.

Wearhead vein: Matrix, fluorspar, with lead-ore.

Black Dene vein: 3 to 5 feet in width; matrix, fluorspar, with lead-ore.

Lodge Field vein: 3 to 5 feet in width; matrix, fluorspar, with lead-ore.

Old Faw vein: 3 to 5 feet in width; matrix, fluorspar, with lead-ore. This vein is supposed to be a continuation of the Boltsburn vein.

Groveheads vein: 3 to 5 feet in width; matrix, fluorspar, with lead-ore.

Carr's vein: 2 to 3 feet in width; matrix, fluorspar, with lead-ore. Fine blue crystals of fluorite are found embedded in the clay.

Dawson's vein: 2 to 3 feet in width; matrix, fluorspar and iron-ore.

Green Laws (Old) vein: 2 to 4 feet in width; matrix, fluorspar, with lead-ore, and also a good mixture of rider.

Green Laws (New) vein: 4 to 10 feet in width; matrix, fluorspar, with lead-ore, with a considerable mixture of carbonate of iron, and crystals of brown and amber fluorspar.

Swinhope Cross vein: A strong fluorspar-vein.

Barbara vein: Matrix, fluorspar.

(*c*) *Bollihope Veins.*—(1) Yew-tree vein: Matrix, fluorspar; formerly productive of lead-ore in the firestone, which is here 16 fathoms thick. (2) Whitfield Brow copper-vein: Matrix, fluorspar; formerly productive of lead-ore. (3) Cornish Hush vein: Matrix, fluorspar; formerly productive of lead-ore. (4) Harehope Gill, Softley, and Park Level veins all contained fluorspar.

(3) *Veins West of the Burtreeford Fault.*—These veins are not favourable for the production of fluorspar. The writer is indebted to Mr. John Thompson, sub-agent, Weardale Lead-mining Company, Limited, for particulars of the following principal veins in the Burnhope and Killhope district:—

Killhope Head vein: 4 to 6 feet in width; matrix, rider, amber, light-blue, and some dull-green fluorspar; "Black Jack" or zinc-blende and lead-ore.

Level Grove vein: 2 to 3 feet in width; formerly productive of lead-ore; rich in extension flats, rider, and a little fluorspar.

Tweed vein: 3 feet in width; matrix, rider; formerly productive of lead-ore.

Old Moss vein: 2 to 3 feet in width; matrix, rider, iron pyrites, lead-ore, and a little fluorspar.

Middle Grove vein: 3 to 4 feet in width: matrix, rider, a little fluorspar, a good deal of "Black Jack," and lead-ore.

Hymers vein, or Park Level: Matrix, rider; herring-bone strings of lead-ore.

Lodge Gill vein: 3 to 4 feet in width; matrix, rider; very little fluorspar.

IV.—Bibliography.

Recent Literature on Fluorspar.—For more extensive details of the development of fluorspar, especially in the United States of America, the reader is referred to the following list, which the writer has taken from various sources:—

Bain, H. Foster, "Fluorspar-deposits of the Kentucky-Illinois District," *Mines and Minerals*, 1904, vol. xxv., page 182.

—, "Zinc and Lead-deposits of Northern Illinois," *United States Geological Survey: Bulletins*, No. 246, 1905.

—, "The Fluorspar-deposits of Southern Illinois," *United States Geological Survey: Bulletins*, No. 255, 1905.

—, "Principal American Fluorspar-deposits," *Mining Magazine*, 1905, vol. xii., page 115.

Bauerman, Hilary, *Textbook of Descriptive Mineralogy*, 1884.

Blake, W. P., "Historical Sketch of Mining in Arizona," *Report of the Governor of Arizona to the Secretary of the Interior*, 1899, page 106.

Burchard, Ernest F., "Production of Fluorspar and Cryolite in 1906," *United States Geological Survey: Mineral Resources of the United States*, 1907.

Dakyns, J. R., C. Le Neve Foster, and A. H. Green, *Memoirs of the Geological Survey of England and Wales: The Geology of the Carboniferous Limestone, Yoredale Rocks, and Millstone Grit of North Derbyshire*, second edition, with additions by A. H. Green and Aubrey Strahan, 1887.

Dana, James D., *A System of Mineralogy*, fifth edition, 1872, page 123.

Emmons, S. F., "Fluorspar-deposits of Southern Illinois," *Transactions of the American Institute of Mining Engineers*, 1892, vol. xxi., page 31.

Fohs, F. Julius, "Production of Lead, Zinc, and Fluorspar in Western Kentucky," *Kentucky State Mine Inspectors' Report*, 1903-1904, chapter v.

—, "Fluorspar," *The Engineering and Mining Journal* [New York], 1906, vol. lxxxi., page 45.

Hovey, Edmund Otis, "Fluorspar," *United States Geological Survey: Mineral Resources of the United States*, 1905, page 1099.

Miller, Arthur M., "The Lead and Zinc-bearing Rocks of Central Kentucky," *Kentucky Geological Survey: Bulletins*, No. 2, 1905.

Phenis, Albert, "Kentucky Fluorspar, Lead, and Zinc," *Manufacturers' Record*, 1906, page 467.

Pratt, Joseph Hyde, "Fluorspar and Cryolite," *United States Geological Survey: Mineral Resources of the United States*, 1904, page 1031.

Rudler, F. W., *A Handbook to a Collection of the Minerals of the British Islands, mostly selected from the Ludlam Collection, in the Museum of Practical Geology*, 1905.

Smith, W. S. Tangier, and E. O. Ulrich, "The Lead, Zinc, and Fluorspar-deposits of Western Kentucky," *United States Geological Survey: Professional Papers*, No. 36, 1905.

Ure, Andrew, *A Dictionary of Chemistry and Mineralogy*, 1831, page 472.

Watson, Thomas, "Lead and Zinc-deposits of Virginia," *Virginia Geological Survey: Bulletins*, No. 1, 1905, page 42.

Wheeler, George D., "Zinc in Crittenden County, Kentucky," *The Engineering and Mining Journal* [New York], 1902, vol. lxxiv., page 413.

Handbook to the Collection of British Pottery and Porcelain in the Museum of Practical Geology, 1893.

A Handbook to the Museum of Practical Geology, 1896.

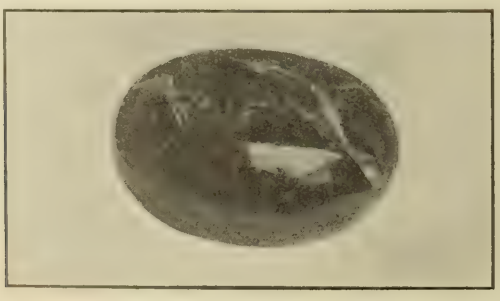


FIG. 5. PAPER-WEIGHT, TURNED AND POLISHED, MADE FROM WEARDALE FLUORSPAR.

Mr. F. W. Rudler (London) wrote that it might not be without interest to call attention to the fact that the late Prof. M. Berthelot undertook some experiments on the colour of the violet fluorspar from Weardale, which have been continued by his son, Prof. Daniel Berthelot. The colour was first discharged from the mineral by the application of heat, and the decolourised fluorspar was then exposed to the prolonged action of a compound of radium, when it was found that the violet tint was gradually restored. It would thus seem possible that the natural colour of fluorspar might be largely influenced by the radioactive matter in the neighbouring rocks, as Prof. Bordas had suggested with regard to coloured corundums. The effect was believed to be due to the *gamma* rays emitted by radium, which had great penetrating power, and might perhaps act specially along the cleavage-planes. In connection with Mr. Egglestone's remarks on the varied colours of fluorspar, it might be mentioned that a large suite of specimens was arranged in the Museum of Practical Geology, London, showing that this species presented nearly all the tints of the rainbow. The octahedral cleavage-cracks, produced by a mere tap on a crystal, often increased its beauty by giving rise to interference-colours from the very thin films of included air. It had been held with much probability that the material of the famous Murrhine vases, so highly valued in Rome, whither they were first brought by Pompey, must have been a purple fluorspar showing iridescence, as described by Pliny. Mr. Egglestone referred to the use of ornamental fluorspar by pre-historic races, and it might therefore be interesting to recall the fact that Dr. E. Dupont, of Brussels, discovered more than forty years ago a limestone-cavern on the bank of the River Lesse, from which he obtained a collection of fossil-shells brought from a distance, with other curious objects, including a piece of fluorspar. They might have been accumulated for purpose of worship, or simply for personal decoration, but it had also been suggested that they were collected as mere curiosities, and, if so, we had here a specimen of fluorspar from a pre-historic museum.

Councillor J. T. Biggs, J.P. (Chairman of the Museum and Art Gallery Committee, Leicester), wrote that he considered Mr. Egglestone's interesting paper a most valuable contribution to

the subject. It might probably interest the members to know that there was a very fine example of a "Blue John" vase in the Leicester museum, the basin of which measured 12 or 13 inches across. The museum also contained some very fine fluorspar cubes, richly irridescent, which he (Mr. Biggs) had obtained from Weardale, in which district he had seen magnificent cubes measuring as much as 8 or 10 inches, and fluorspar in every variety of colour. The commercial value and uses of fluorspar were likely to considerably appreciate in the near future.

Mr. J. H. Collins (London) wrote that it would probably interest the members to know that, twenty years ago, the uncleavable and highly phosphorescent variety of fluorspar—chlorophane—which yields a bright green light when moderately heated, was rather abundantly found in the Great Lode at East Pool (Cornwall). He might also say that purple fluorspar occurred as a constituent of the granite, and also as a coating of minute cubes in the joints thereof, at Wheal Damsel, and other places in Cornwall. It also occurred similarly in the chinastone of St. Stephens and St. Dennis in Cornwall, and at Montebras in Central France.

Mr. S. Watson (Ireshopeburn, Weardale) wrote that the Weardale fluorspar-veins did not appear to be influenced by the adjacent rocks or walls. The mineral was as plentiful in siliceous as in calcareous rock, differing in that respect from its associated mineral, galena, which was generally more abundant in the latter. Mr. Egglestone had collected various opinions as to the origin of fluorspar in veins, and argued against its source being found in the enclosing country rock. He (Mr. Watson) scarcely thought that the author was justified in assuming that the ironstone-deposits on the side of the Weardale veins were evidence of enrichment from the vein. The fissuring of the rocks, tapping the ferruginous solutions of the shale-beds, would provide an adequate supply. Mr. Egglestone had evidently made a close study of fluorite in the crystal; and perhaps no other mineral illustrated so well the growth or deposition of minerals in general. The decay of fluorite was also noticed, and the question was suggested: what was the nature of the fluid or gas which dissolved it, leaving untouched thin crusts of quartz, calcite, and siderite? As a guide to the study of this interesting and useful mineral, he considered Mr. Egglestone's paper of great value.

Mr. B. L. Bradley (Grindleford) wrote that he had read Mr. Egglestone's paper with considerable interest, as his duties brought him constantly in touch with lead and spar-mining operations in Derbyshire. He congratulated Mr. Egglestone on the able manner in which he had tackled so difficult a subject; not only from an engineering and geological standpoint, but also from the chemical and commercial side, and his knowledge of the subject was so full, that he had scarcely left a loophole for argument.

With respect to the chief Derbyshire deposits, the best were to be found in North-west Derbyshire, of which the main were the Moorfurlong pipe and cross-cuts in the Bradwell district, and the High and Deep Rakes in the Longstone district. "Blue John" was found in varying quantities, but not to any great extent; the shade of the heavy deposits was generally pale pink, although sometimes the mineral occurred as a colourless crystal: the sides of the cubes rarely exceeding $\frac{3}{8}$ inch. The pipes were ellipsoidal, the fluorspar lying convex to the transverse axis, but sometimes alternating with layers of barium sulphate and limestone; the fluor-beds varied in depth from $1\frac{1}{2}$ to 10 feet. The thickness of the fluorspar in the master-veins was from 3 to 12 feet, and occasionally reached 15 feet; and in the cross-cuts the thickness was from 1 to 3 feet.

With regard to the commercial side of the paper, he quite agreed with the author that the Weardale and the Allendale fluorspars were excellent, and he thought that they were ahead of the spars in the Derbyshire district as regarded beauty and symmetry of form, when taken in bulk; yet he might say that there existed excellent specimens of modelled fluorspar made of the "Blue John" of Derbyshire, which were fine works of handicraft and art. A fine polished pillar and pedestal of "Blue John" stood in the mineral-room of Chatsworth House, and in the writer's opinion, as well as that of others better able to judge, this work excelled many others of similar design in Grecian marble. Of late years, however, very little had been done in fluorspar-modelling, owing to the increased export of the mineral for smelting industries. As a flux, taking the spar *en masse*, he was of opinion that the Derbyshire deposits were preferable; and this opinion had been confirmed by practical steel-producers and others engaged in smelting. This opinion was based

upon the following points:—(1) Derbyshire fluorspar was freer from sulphides, thereby reducing the sulphur, and also contained less silica; and (2) owing to its soft nature, it did its work more quickly. Records showed that fluorspar had been used as a flux before 1730. He had seen one record, made by a Mr. Hawes when touring this country prospecting for minerals on behalf of Spaniards in the year 1800, which contained the following remark:—"I noticed at Castletown [Castleton], in Derbyshire, that the metal-smelters used a flux known as 'smelting sugar,'* which was also called 'Blue John.'"†

Mr. W. M. Egglestone (Stanhope) wrote that he was glad to know that his paper on fluorspar had been of some interest to the members of the Institute, and he welcomed with much pleasure the remarks of Mr. Rudler and others on some additional properties of that beautiful mineral.

With reference to Mr. Watson's remarks that "he (Mr. Watson) scarcely thought that the author was justified in assuming that the ironstone deposits on the side of the Weardale veins were evidence of enrichment from the veins," and that "the fissuring of the rocks, tapping the ferruginous solutions of the shale-beds, would provide an adequate supply,"‡ he (Mr. Egglestone) was of opinion that he was, from good authority, justified in assuming that "the metasomatic action which converted the limestone into ironstone is evidence of rock enrichment from the metalliferous vein,"§ and would state that the iron ores of the North of England mining field were well described more than 50 years ago by the officers of the Geological Survey.‖ Referring to Alston Moor district, it was pointed out that some of the lead veins, in a part of their course, were charged with brown iron-ore instead of the usual fluorspar and quartz and its concomitant lead ore. The rich lode of Roderup Fell seen in the

* The smelters in South Derbyshire thirty years ago sent vehicles to Bradwell for "furnace-sugar."—B.L.B.

† Mr. James Hawes was an English geologist whose services were retained by the Spanish Government to prospect for minerals, and the quotation is from the records of that gentleman.

‡ *Trans. Inst. M. E.*, 1908, vol. xxxv., page 264. § *Ibid.*, page 251.

‖ "Iron-ores of the Northern and North-midland Counties of England (Cumberland, Durham, Northumberland, Lancashire, Yorkshire, and Derbyshire)," by Mr. Warington W. Smyth, *Memoirs of the Geological Survey of Great Britain and of the Museum of Practical Geology: The Iron-ores of Great Britain*, 1856, page 17.

Scar Limestone was a vein of brown iron-ore from 16 to 20 feet wide. The Manor House vein, near Alston railway station, was 14 feet wide, and from wall to wall produced nothing but this kind of ore. In the veins in Killhope (Weardale), it was stated, were found corals, characteristic of this formation, enveloped and entirely fossilised in brown iron-ore, and it was noted that a curious series of changes had probably operated on the fossiliferous limestone which at one time formed the walls or sides of the vein (metasomatic action). In Stanhopeburn the veins were so charged with this iron-ore that a large area of ground was bodily removed by the Weardale Iron Company, and a considerable quantity of lead ore was separated during the operation. The Rispey vein in Rookhope contained this brown peroxide of iron spreading over a width of 30 to 40 feet. It was considered that brown iron-ore was due to the decomposition and that it was originally placed *in situ* in the conditions as a carbonate. Mr. Kendall has pointed out that this ore or rider assumes two forms, first as ribs from a few inches to 20 feet in width and that if one of the sides or walls of the vein is limestone and the other sandstone, the ribs of iron-ore are to be found on the limestone wall; if both are limestone, iron-ore is found on both walls, and where the iron-ore adjoins the limestone there is a gradual passage from one to the other, that is, from ore to limestone and limestone to ore.* The same writer, referring to the limonites and siderites of Weardale and Alston, says—" There cannot be any doubt that the siderite, which was the original ore here, and from which the limonite was produced by alteration, was formed by the replacement of limestone. The growing together of the two minerals, where they are in contact, is alone sufficient to prove this."† As to where the original iron which filled the veins came from is another matter, and an important one. The Coal-measures, which constitute a considerable storehouse of iron-ore, have been mentioned; also the Permian rocks, and the Carboniferous Limestone shales, as above mentioned, which are depositing limonite at the present day. Then there are the thermal springs and the influence of igneous rock, as also the introduction of iron in a gaseous form from deep-seated sources.

* *The Iron-ores of Great Britain and Ireland*, by Mr. J. D. Kendall, 1893, page 142.

† *Ibid.*, page 327.

It may be mentioned that the author of *A Manual of Mineralogy*, dealing with the minerals of Cornwall, 1825, states that the most beautiful varieties of fluorspar in that district had been found at St. Agnes, and one purple specimen, in crystallised cubes, had "every plane or face exhibiting a flat four-sided pyramid, so as to form a solid, bounded by 24 triangular planes,"* and that chlorophane of a violet-blue colour, and which threw out a beautiful emerald-green colour when heated, had been found in Pednandrae Mine, Redruth. Mawe mentions blue fluorspar with four-sided pyramids on each face, and also crystals with enclosures and bevelled edges.†

Mr. Egglestone, in conclusion, thanked the President and members for their unanimous vote of thanks, and wished also to express his obligations to Mr. Lawrence Austin for the courteous assistance rendered to him by that gentleman in the preparation of the paper.

On the motion of the PRESIDENT, a vote of thanks was unanimously passed to the writer of the paper.

---

* *A Manual of Mineralogy;* in which is shown how much Cornwall contributes to the illustration of the science. Anonymous, 1825, page 131.

† *The Mineralogy of Derbyshire*, by Mr. John Mawe, 1802, page 76.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

EXCURSION-MEETING,
HELD AT SOUTH BANK, OCTOBER 30TH, 1907.

CARGO FLEET STEEL- AND IRON-WORKS.

The properties of the Cargo Fleet Iron Company, Limited, consist of ironstone-mines at Liverton, in Cleveland, limestone-quarries at Mickleton, in Teesdale, and coke-ovens, bye-product plant, blast-furnaces, steel-furnaces, and rolling-mills at Cargo Fleet, near Middlesbrough.

The Cargo Fleet steel- and iron-works, which were visited by the members, comprise a Humboldt coal-washer, capable of dealing with 60 tons of coal per hour. The coal is taken direct from the washery to a central coal-bunker, situated between two batteries, each of fifty coke-ovens, of the Koppers regenerative type.

Attached to the coke-ovens is a bye-product plant for dealing with the waste-gases, out of which are manufactured tar and sulphate-of-ammonia; and it is in contemplation to add a benzole-plant.

From 40 to 50 per cent. of the gas produced at the coke-ovens is utilized, after being purified, in driving two Premier gas-engines, each of 500 horsepower, for generating electricity: the remainder being used at the steel-works, in the place of producer-gas, for firing mixers.

The coke, when drawn from the ovens, is delivered from an inclined bench into electrically driven coke-cars, which in turn deliver it into small bunkers, whence it is conveyed by travelling-skips or belts into the furnace-hoist skip, being then charged into the blast-furnaces by means of self-tipping furnace-charging appliances.

Between the two batteries of coke-ovens, which are situated immediately behind and parallel with the range of blast-furnaces,

stand two large parabolical bunkers, divided into compartments, for the storage and delivery of the ores and limestone used in the manufacture of pig-iron. A very fine overhead gantry traverses the whole length of the range of bunkers, and large open spaces are provided where stocks of ore can be deposited for future use.

There are two furnaces at present erected, and provision has been made for the erection of others. Those erected are each 90 feet high with 11 feet hearth and 21 feet bosh, and have each an output capacity of about 1,400 tons, when working on Cleveland ironstone. The blast is supplied by seven gas blowing-engines of the Cockerill type, each capable of delivering 14,000 cubic feet of free air per minute, at a pressure of 10 to 12 pounds per square inch. The blast generated is fed into the blast-furnace through a range of Cowper fire-brick stoves, twelve in number, 55 feet high to the springing of the dome.

The gas from the blast-furnaces provides the heating power for the Cowper stoves, and the spare gas, after being washed in Theisen gas-washers, of which there is an installation of three, two of which are capable of dealing with the whole of the gases from the furnaces, amounting to about 1,800 cubic metres per minute, is used firstly for driving the gas blowing-engines; secondly for driving two electric generators, each of 375 kilowatts; and thirdly for generating steam in the boilers driving the rolling-mills.

The company have a very fine electric installation, and supply all the power and lighting required for the works. The plant consists of one compound steam direct-driving set of 350 kilowatts; two steam turbo-generator sets, each of 750 kilowatts; two Premier gas-engine generator sets, each of 300 kilowatts; and two gas-engine generator sets, each of 375 kilowatts, already referred to. The generators all run in parallel on a 220-volt continuous-current circuit, the load being distributed by one large switchboard of six panels.

The metal from the blast-furnaces is taken in a molten condition in large ladles on cars, direct to the steel-furnaces or to the mixers. The steel-smelting plant consists of three Talbot furnaces, each of 175 tons capacity, and another of 250 tons capacity. The metal is there converted into steel by the Talbot continuous process. This process has been well described by Mr.

Benjamin Talbot in a paper* read before the members of the Iron and Steel Institute, and also in subsequent papers which have been read before the same Institute. Briefly, it consists in converting, in a large bath, the molten metal into a proper condition for casting into steel ingots, and withdrawing about one-third of the molten steel, then adding to the remainder of the steel in the bath lime and oxides, forming a highly oxidizing calcareous slag at a high temperature. When in this condition, molten metal is poured into the furnace, either direct from the blast-furnaces or from the mixers. A violent reaction immediately takes place, and the metal in the bath is quickly worked down again into a soft condition. The process is continuous throughout the whole week, and the furnace is only emptied at long intervals for repairs. The steel is run into 50-ton capacity ladles which are then taken by 75-ton overhead cranes, of which there are two, and run into ingot-moulds standing on cars which are moved by a hydraulic pusher. On the cars the ingots are run by a locomotive under the stripper, where the moulds are taken off, and the ingots are hauled forward and taken up by an electric overhead crane and lowered into soaking-pits. From these pits the ingots are again taken by an overhead crane and laid on to a tilting-chair at the end of the cogging-mill live roller-gear.

The cogging-mill is of the most powerful type. It consists of a mill, with rolls 8½ feet wide and 40-inch centres, driven by a three-cylinder compound condensing-engine of 45 inches and 52 inches stroke. The three cylinders are all of the same size, one being high-pressure and two low-pressure: but by the use of valve-gear they can all be operated as high-pressure cylinders.

After the ingots have been cogged down to the required size, they are conveyed by live roller-gear, electrically driven, to the hydraulic bloom-shears, where they are cut into the required lengths and transferred on to a Collins charger, which delivers them into two gas-fired re-heating furnaces preparatory to the finishing process. The same charger withdraws the blooms from the re-heating furnace and delivers them on to the live roller-gear of the finishing mill.

* "The Open-hearth Continuous Steel Process," by Mr. Benjamin Talbot, *The Journal of the Iron and Steel Institute*, 1900, vol. lvii., page 33.

The finishing mill is provided with two travelling tables, one on each side of the rolls, which enables rapid transference from the first pair of rolls to the intermediate and the last.

From the finishing mill the product is carried forward on live roller-gear to the hot saws, where it is sawn to the required lengths and delivered on to the hot banks. The engine for the finishing mill is practically a duplicate of the one for the cogging mill.

The boiler plant consists of one Nesdrum and eight Babcock water-tube boilers, for the electrical plant, and subsidiary steam-engines, and of ten Nesdrum and two Lancashire boilers for the rolling-mills.

There is one central condensing-plant of the Weiss type, capable of dealing with all the steam from three mill-engines, of which two only are installed.

The Company is at present chiefly engaged in the manufacture of shipbuilding sections, joists, and channels and rails. The works are favourably situated at the junction of the old Cleveland railway and the North-eastern Railway Company's Middlesbrough to Saltburn line, with sidings on both railways. The Company owns about 140 acres of foreshore land, which is being utilized for slag tipping, and thereby brought into a condition fit for the erection of any important industrial works. It has direct communication between its works and its own wharf on the river Tees, where vessels of 5,000 tons burden can be loaded or discharged. The depth of water in the berth is 16 feet at low water on spring tides. The works are very fully equipped with every class of machinery for dealing economically and speedily with its products or appliances, and have very large repairing, smith's, and boiler-shops, so making them quite independent of outside engineering establishments.

The raw material for the blast-furnaces is chiefly Cleveland ore, produced at the Company's own mines at Liverton, where they own a royalty over about 2,500 acres.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
JUNE 20TH, 1908.

MR. JOHN H. MERIVALE, PRESIDENT, IN THE CHAIR.

The ACTING SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on May 30th and that day.

The PRESIDENT (Mr. John H. Merivale) said that the principal matter in connection with the proceedings of the Council was the appointment of an Honorary Secretary, Mr. T. E. Forster having kindly undertaken that office. He was sure that this would be very gratifying to the members, and they would feel that they owed a debt of gratitude to that gentleman. Whether he was likely to hold the appointment very long or not remained to be seen.

The ACTING SECRETARY read the balloting list for the election of officers for the year 1908-1909.

PORTRAITS OF PAST-PRESIDENTS AND SECRETARIES.

Mr. T. E. FORSTER (Newcastle-upon-Tyne), on behalf of those who had presented portraits of past-presidents, said that he had much pleasure in handing these over to the keeping of the Institute, and he felt that it was very appropriate that this

should take place during the presidency of Mr. Merivale. The scheme of hanging the portraits of all the past-presidents in the Lecture Theatre was promulgated some six years ago, but it was due to Mr. Merivale that it had been completed, and they all felt very much indebted to him.

The President said that, in the name of the Institute, he had very great pleasure in accepting the portraits. He had certainly taken an interest in the matter, but so had others. Mr. J. G. Weeks, he remembered, was in the chair when the movement was initiated, and Mr. Thomas Douglas presided when it was confirmed. The matter had, however, hung fire until Mr. T. E. Forster came forward and presented the portraits of his progenitors: his grandfather and father; and he was very pleased to see that in the course of two years or more there was a strong probability of Mr. Forster's own portrait gracing the walls. It would be very interesting to see thereon the portraits of father, son, and grandson. He thought that Messrs. James Bacon & Sons were to be congratulated on the excellent and artistic way in which the work had been carried out, and the members cordially thanked Mr. Forster for undertaking in the name of the donors to present the portraits to the Institute.

Mr. Thomas Douglas (Darlington) said that they would all feel that a pleasant duty had been performed that day. It was gratifying for many reasons. They did not live for ever, and it was pleasant to think that the men who had presided over the Institute from its earliest period should have an opportunity of being seen in future years. Photography was now such an excellent institution and so valuable that they ought not to be without photographs of those friends and members of the Institute. It was pleasant by such means to revive one's recollection of them after they had passed away. The possession of the portraits he considered to be a valuable acquisition to the Institute.

Mr. A. L. Steavenson (Durham) supported what had been said by Mr. Douglas, who was one of the original members of the Institute. His own connection dated from 1855, and he believed that they had both done their duty to the Institute. They had attended as many meetings and written as many papers as most people, and had always taken a great interest in the proceedings. He

thought that interest had been fully returned, for he always found that there was more benefit to the writer of a paper than to those who sat and listened to it. In writing a paper they divided the subject into heads and then filled it up with what information they could collect from all kinds of sources. His first paper, written in 1859, and read in 1860, was "On the Manufacture of Coke in the Newcastle and Durham District."* It certainly did him a great deal of good, and he believed that it was the means of obtaining for him the position which he had held ever since. If he spoke well of the Institute, the benefit was mutual and very great. He would point out to the younger members that there was still a number of vacant places in their portrait gallery for future presidents, and he hoped that they would strive to do their best to fill them. The late Mr. Nicholas Wood was president for eleven years after he (Mr. Steavenson) became a member. There were now very few of the original members, and he believed that only six remained who were members when he joined the Institute. It therefore gave him great pleasure to be able to take part in that day's proceedings.

Mr. J. G. Weeks (Bedlington) also endorsed the remarks made by the previous speakers, and said that he was glad to see the lecture theatre, which was more or less identified with his term of office, furnished with the portraits. He believed that only five of the original members now remained, namely, Mr. Thomas Douglas, Mr. Cuthbert Berkley, Mr. A. S. Palmer, Mr. William Spencer, and Mr. John Rutherford, of Halifax, Nova Scotia.

The following gentlemen were elected, having been previously nominated:—

Honorary Member—

Mr. Daniel Murgue, Ingénieur Civil des Mines, 1, Rue St. Honoré, St. Étienne, Loire, France.

Members—

Mr. Edward Cowell, Colliery Manager, Shotton Colliery Offices, Shotton Colliery, Castle Eden, S.O., County Durham.

* *Trans. N. E. Inst.*, 1860, vol. viii., page 109.

Mr. George Victor Septimus Dunn, Mineralogist and Consulting Mining Engineer, 7, St. James' Buildings, William Street, Melbourne, Victoria, Australia.

Mr. Alfred Hewlett, Managing Director of The Cossall Colliery Company, Limited, Cossall, near Nottingham.

Mr. Joseph Parker Hindmarsh, Inspector of Collieries, Corrimal, South Coast, New South Wales, Australia.

Mr. Kingsley Hopwood, Mining, Mechanical and Electrical Engineer, Beech Leigh, Buckley, Chester.

Mr. Daniel Hotchkis, Colliery Manager, Mount Kembla Colliery, Wollongong, New South Wales, Australia.

Mr. Albert Jennings, Works Manager, 12, Grainger Street, Darlington.

Mr. Edward Morrison, Colliery Manager, 51, Pica Cottages, Distington, S.O., Cumberland.

Mr. William Frederick Price, Engineer, A Floor, Milburn House, Dean Street, Newcastle-upon-Tyne.

Mr. David Thomas, Civil and Mining Engineer, Quay Street, Ammanford, S.O., Carmarthenshire.

Mr. Charles Edward Turner, Mining Engineer, Mina Campanario, Valverde del Camuio, Provincia de Huelva, Spain.

Mr. Foster Williams, Mining Engineer, Miniera di Libiola, Sestri Levante, Italy.

Associate Member—

Mr. George Ralph Gibson, Tyne Saw Mills, Hexham.

Associates—

Mr. Hugh Clarkson Annett, Mining Student, Widdrington, Acklington, S.O., Northumberland.

Mr. Percy Lindsay Lascelles, Colliery Surveyor, Coundon, Bishop Auckland.

Students—

Mr. Norman Elsdale Barber, Mining Student, Seghill Colliery, Seghill, Dudley, S.O., Northumberland.

Mr. Stanley Walton Brown, Mining Student, Seghill Colliery, Seghill, Dudley, S.O., Northumberland.

DISCUSSION OF MR. W. M. EGGLESTONE'S PAPER ON "THE OCCURRENCE AND COMMERCIAL USES OF FLUORSPAR."*

Mr. Benjamin L. Bradley (Grindleford, Derbyshire) wrote submitting three pieces of Derbyshire fluorspar from the Moorfurlong mine, which were good average specimens. The fluorspar would be found of rather a softer nature than that obtained from Weardale.

Mr. David Burns (Carlisle) wrote that Mr. Egglestone had

* *Trans. Inst. M. E.*, 1908, vol. xxxv., page 236.

brought forward a subject of great interest. If ever they were to know much of the contents of the metalliferous lodes of the Dales, at any rate in the form in which they now found them, it must be by a careful study of the succession of crystals, and an explanation from chemists of the conditions necessary for each succeeding formation. To get full value of the arrangement of the crystals in a specimen, it should be carefully observed before it was broken from its original seat. Mr. Egglestone had referred to the common phenomenon of small crystals coating one side of a large crystal, whereas another side might be destitute of coating. If the specimen before being disturbed had the coated faces of the crystals on the upper side, and there only, they would be justified in assuming that this secondary mineral had been precipitated either as dust from a gaseous envelope, or in some other form from a liquid one. Then, if covering the western faces only, say, the secondary mineral had been brought by a strong current from the west. All these important data were lost when the specimen had been broken off without due notice having been taken and recorded. He (Mr. Burns) had in his possession a specimen which he had obtained many years ago in West Allendale, which he believed came from the Carshield mine, but of this he was not quite sure. The specimen showed the following stages:—

(1) Fluorspar had been deposited with a free surface, allowing of the formation of perfect crystals; (2) on these crystals had been deposited a thick quartz coating; (3) the fluorspar had been later completely removed; and (4) on the back of the quartz, that was, in the position formerly occupied by the fluorspar, had been deposited at a still later period a beautiful crystal of blende of considerable size. Now, surely chemistry should be able to tell them more of the conditions under which those four operations were possible, nay, inevitable, than it had yet done. It was to chemists alone that they must look for the necessary information, and it was scarcely to their credit that this fascinating subject should be in so backward a condition.

Mr. W. M. Egglestone wrote stating that he quite agreed with Mr. Burns that observation as to the position of crystals when *in situ*, and before removal, was desirable. It was most important in connection with the question of minerals investing other

minerals; and he had, when preparing his paper, made enquiries of miners, and had been informed that in the cavities or vughs where fluorspar in crystals was generally found, the upper faces only were those invested with secondary minerals; but this point required further investigation and confirmation. Considering that water-vapour never condensed except upon a solid substance, and that all condensation of water-vapour in the air, whether rain, mist, fog, cloud, or snow, took place on a nucleus of dust,* it might be asked whether dust-motes had anything to do with this process so far as scattered crystals were concerned. If a dust-mote was necessary to the formation of a drop of rain, would dust-motes settling upon the clean upper surface of a fluorspar cube in a cavity induce the formation of investing crystals?

Hand-specimens of fluorspar, showing crystals invested apparently on the sides, might, when in their natural home in the cavity in the mine, show that the invested sides were, in nature, uppermost. Fluorspar had evidently been, in many metalliferous veins, the early mineral; and in many mines pseudomorphs or isomorphs showed that the original fluorspar, after being overlain or covered with other minerals, had been dissolved out, leaving an empty mould. These hollow imprints of fluorspar were common in Boltsburn mine, Weardale, one of them, in the possession of the writer, having the inside of the mould studded over with quite a number of pea-sized crystals of zinc-blende, deposited, of course, after the fluorspar had disappeared.

The writer had also in his possession an interesting specimen from the Sedling mine, Weardale: a solid angle of fluorspar, broken off in the mine, and having edges extending to some 4 inches. This solid angle had been completely covered with quartz, $\frac{1}{4}$ inch thick. This quartz-cap had, in like manner, been completely covered with beautiful bluish-purple crystals, with sides measuring as much as $\frac{1}{2}$ inch, and the shape of the original solid angle of fluorspar was fairly well maintained. This third deposit formed a handsome and instructive specimen of crystalline fluorspar.

---

* *The Realm of Nature*, by Hugh Robert Mill, 1892, page 113.

DISCUSSION OF MR. THOMAS HARKER'S PAPER ON "FLINTY CHERT, HORNSTONE, ETC."*

Mr. Thomas Harker wrote submitting samples of flinty chert which he had obtained in Arkengarthdale, Yorkshire, and which were taken from a bed 6 feet thick. The difference in quality was distinguishable by the shade or colour. The brightest and most marble-looking lay about 15 feet in thickness at the top of the 16-foot bed; the darker colour was from the bottom part of the bed, and was not so good in quality; whilst a third sample had been tested, and proved to be of excellent quality.

Mr. J. B. Atkinson (H.M. Inspector of Mines, Newcastle-upon-Tyne) thought that they would have had some communication from Prof. Lebour on the subject. He had discussed the matter with him, and his (Prof. Lebour's) opinion was that chert was due to the replacement of the limestone by silica. Evidently he (Mr. Atkinson) was wrong in the view that he expressed at the last meeting that possibly their gannister beds might be equivalent.†

Mr. J. P. Kirkup (Burnhope) said that the samples submitted brought to his mind a visit to Flamborough Head, where, in the chalk cliffs, they found samples of rather better quality than the best of those now exhibited. Apparently the conditions were similar to those found to exist in the Carboniferous Measures.

Mr. W. M. Egglestone (Stanhope) wrote that he agreed with Prof. Lebour that chert was due to the replacement of the limestone by silica. John Mawe referred to the Derbyshire chert, a siliceous substance used by the potters, as being found in the limestone in large detached masses, and in thin strata, near Castleton, Matlock, and other places, and stated that it was "full of marine figures, and animal remains; in which respect it resembles the limestone, as though it had undergone a transition into petrosilex, or what the French called keralite."‡ It would be interesting to know whether any fossil organisms existed in the Yorkshire cherts.

* *Trans. Inst. M. E.*, 1908, vol. xxxv., page 231.

† *Ibid.*, page 233.

‡ *The Mineralogy of Derbyshire*, by John Mawe, 1802, page 31.

DISCUSSION OF MR. H. W. G. HALBAUM'S PAPER ON "CAST-IRON TUBBING: WHAT IS ITS RATIONAL FORMULA?"*

Mr. H. W. G. Halbaum (Horden) wrote that as Prof. Louis and Dr. Morrow had not seen fit to withdraw, modify, or justify certain remarks they had made in the previous discussion of the paper, he felt it necessary to examine those utterances a little more fully. That necessity arose from the fact that the scholarly status and collegiate environment of those critics might invest their strictures with a glamour which many might mistake for logic and light.

First, with regard to the place of corrosion, it was only necessary to say that if Prof. Louis could state the case more definitely, he (Mr. Halbaum) would be pleased to see him succeed in doing so.

Secondly, Prof. Louis had stated that he (Mr. Halbaum) had "quietly disregarded the main difficulty of the whole problem, inasmuch as he had treated a ring of tubbing as a plain cylinder, which was precisely what it was not."† With regard to the office of the ribs and flanges, the author had devoted nine pages of his paper to the careful consideration of this question;‡ whilst with regard to the segmental structure, that, also, was fully considered in Appendix III.,§ and illustrated by four figures on plate xxiii. If Prof. Louis had recognized the simple fact that segments of tubbing were merely frustums of wedges, his so-called main difficulty would have vanished, and he would have clearly seen that the ordinary design of tubbing-ring emphatically resolved itself into the case of the plain cylinder.

Thirdly, Prof. Louis had gone on to say: "It was quite unnecessary for Mr. Halbaum to trouble about the simple case of the plain cylinder, ... because that comparatively simple problem . . . . had been solved long ago."‖ That was another of Prof. Louis' misfires, for Prof. Jamieson, who might justly be regarded as the Rankine of the twentieth century, distinctly stated that the problem was not solved even yet, and that an accurate solution of the problem was simply impossible.

* *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 567. † *Ibid.*, page 624.
‡ *Ibid.*, pages 584-593. § *Ibid.*, pages 608-609. ‖ *Ibid.*, page 624.

Beyond showing, however, that the case of the tubbing-ring really resolved itself into the "simple" case of the plain cylinder, he (Mr. Halbaum) had hardly troubled himself in the way which Prof. Louis described. The main object of the paper had been to rescue the case of the cylinder from the sciolistic and contradictory formulæ under which certain men—Prof. Louis himself, the co-sponsor for the now abandoned formula of Prof. Galloway, amongst them—had for years endeavoured to obscure it. The formula, for instance, for which Prof. Louis himself was jointly responsible, proceeded on the absurd assumption that the area of the outside pressure was less than the area of the inside surface of the tubbing: that cast-iron doubly thick was more than doubly strong; that corrosion was a myth of the imagination; and that the safe stress might always be taken at one-third of the ultimate crushing-stress of the metal. Prof. Louis had since advocated factors of safety five times as large, and yet he talked of the "simple case of the plain cylinder" being "solved long ago."

But Prof. Louis had enlisted the services of Dr. Morrow in the solution of the tubbing problem, and attention might be called to the positions which the latter had chosen to take up. The first point attempted by Dr. Morrow was to frame a great indictment of the logarithmic formula propounded by him (Mr. Halbaum). That attack was remarkable for several peculiarities. First, Dr. Morrow's attack was unnecessary, since nothing would be gained by it, even if it succeeded. Both Dr. Morrow and himself had stated an "accurate" rule, and an approximate and easier rule for practical use. The relative results (or thicknesses of tubbing stated as percentages of the inside radius) of each rule were set forth in the annexed table.

It was evident from the above table that the differences of the rules, within the limits of the tubbing case, at any rate, were practically *nil*, so that in the extremest tubbing case, Dr. Morrow's "accurate" formula, so-called, would give a thickness about one-quarter of one per cent. less than the thickness directed by the hyperbolic rule. In all other cases, the difference would be less even than that small amount—an amount which in practice would hardly be considered measurable, and

which, in the ordinary tubbing case, would not be measurable. For example, in a shaft 16 feet in diameter, having tubbing of the unheard-of thickness of 9 inches, by the hyperbolic formula, Dr. Morrow's theoretical formula would give the thickness one-hundredth of an inch less. Hence, the first point would be perfectly clear, namely, that Dr. Morrow's contentions could have no tangible result, even if members accepted them. It seemed to the writer, therefore, that it was a pure case of "Much Ado about Nothing."

TABLE SHOWING RELATIVE THICKNESSES OF TUBBING (IN PERCENTAGE OF INSIDE RADIUS) REQUIRED FOR PRESSURE ONLY.

By Halbaum's Hyperbolic Rule.	By Halbaum's Practical Rule.	By Dr. Morrow's "Accurate" Rule.	By Dr. Morrow's Practical Rule.
1·00	1·00	1·00	1·00
2·00	2·00	2·00	2·00
3·00	3·01	3·00	3·00
4·00	4·01	4·00	4·00
5·00	5·02	5·00	5·00
6·00	6·03	6·00	5·99
7·00	7·03	6·99	6·99
8·00	8·04	7·99	7·98
9·00	9·05	8·99	8·97
10·00	10·06	9·98	9·96
11·00	11·07	10·98	10·95
12·00	12·07	11·97	11·93
And so on up till $p = \frac{1}{4}f$, at which point the relative thicknesses become :			
43	$41\frac{2}{3}$	$41\frac{1}{2}$	40

Secondly, it could easily be proved that Dr. Morrow's arguments were inconsistent and self-destructive. After speaking against the hyperbolic rule, Dr. Morrow had been reminded that Prof. Jamieson himself used it for cylinders under internal pressure. Brought face to face with that awkward fact, Dr. Morrow had straightway jumped to the idea that he (Mr. Halbaum) had adapted Jamieson's internal-pressure rule to meet the external-pressure case illustrated by the tubbing problem. That was not so, as anyone might see by referring to Appendix III. of his (Mr. Halbaum's) paper,* where the hyperbolic rule for external pressures was independently deduced from simple first principles. In that appendix, it was also shown that the Aldis rule (which was Dr. Morrow's "accurate" rule) was simply an approximation to the hyperbolic rule, but one near enough for all practical purposes. Hence, if the hyperbolic rule were discredited, Dr. Morrow's so-called

* *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 607.

"accurate" rule would go by the board, a fact which could be verified by comparing columns 1 and 3 of the above table.

With regard to Dr. Morrow's practical formula, the use of which he (Dr. Morrow) was pleased to recommend "under all circumstances," the relative results of that rule were set forth in column 4 of the above table.

Dr. Morrow had stated that: "It was, perhaps, worth while to point out that a formula might give excellent results when used in connection with internal-pressure problems, and yet be at fault in the case of external pressures. It must always be borne in mind that, even for cylinders under internal pressure, the only reason why the logarithmic formula might be used was because it gave results which agreed more or less closely with the more accurate theory."* The "more accurate theory" alluded to thus was, of course, the Aldis approximate theory. But Dr. Morrow went on to show, in his way, how different it was in the case of external pressure, and said "how wrong it was to take a formula obtained for cylinders under internal pressure and to endeavour to amend it to suit the external-pressure problem."† Yet that was precisely what Dr. Morrow himself had done, the proof being as follows:—

Prof. Jamieson gave the following rule for cylinders under internal pressure:—‡

$$\text{Log}_e \frac{R}{r} = \frac{p}{f} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

But since many men prefer the direct arithmetical method, Prof. Jamieson remarks that:

$$\text{Log}_e \frac{R}{r} = \frac{2(R-r)}{R+r} \text{ very nearly} \quad . \quad . \quad . \quad (2)$$

provided that $\frac{R}{r}$ was not greater than 2.§ Substituting that value of $\frac{R}{r}$ in equation (1) above, they got for the thickness:

$$t = \frac{pr}{f - \frac{p}{2}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

* *Trans. Inst. M. E.*, 1908, vol. xxxv., pages 68-69.

† *Ibid.*, pages 70-71.

‡ *Text-book of Applied Mechanics*, by Prof. Andrew Jamieson, second edition, 1900, vol. ii., page 248.

§ *Ibid.*

which was Jamieson's practical formula for cylinders under internal pressure. But if by r they understood the external instead of the internal radius, and if by f they understood the safe compressive instead of the safe tensile stress, Jamieson's formula for the internal-pressure case became Dr. Morrow's rule for the external-pressure problem. That was the Doctor's formula (11); it was "recommended under all circumstances"; and it was simply Jamieson's formula for cylinders internally pressed, "amended so as to apply to the external-pressure problem" by Dr. Morrow himself. His "recommended" formula for external pressure "under all circumstances" was merely an approximation to Jamieson's approximation to the standard for the internal-pressure problem. The Doctor's condemnation of "approximations" thus applied only to his own formulæ.

But the logarithmic formula propounded by the writer was deduced independently for the external-pressure case. Anyone could prove that by referring to the appendix above-named. The late Mr. M. Walton Brown, in his energetic way, had pressed the writer to get the paper ready for the meeting of The Institution of Mining Engineers, held in London in June, 1907; otherwise, the said appendix would have formed an integral portion of the body of the paper. Its object was to show that the case of the cylinder—so far as that could be understood—was simple enough to be stated without the use of the calculus, no matter whether the cylinder was a continuous ring or a jointed structure built up by frustums, as the writer treated them; or by tubbing-segments, as the miner would call them; or by arches "resting against abutments constituted by the rest of the ring, with the peculiarity that the thrusts on such an arch took place along radial lines," as Prof. Louis had happily and precisely put it.* And in all that lengthy discussion, there had not been the slightest attempt to controvert the reasoning which the writer had adopted in that appendix. All Dr. Morrow's criticism had been directed against the writer's methods of comparison of formulæ, and not at all against the much more important question of his methods of deduction. Comment on that fact was unnecessary.

Dr. Morrow had stated that "Sir W. Fairbairn's formula

* *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 624.

. . . . was not to be mentioned in connection with short or over-ringed tubes." Precisely; that was what he (Mr. Halbaum) had emphatically urged. But it was surprising that Dr. Morrow should say so, since Dr. Morrow's formula (24) was directly deduced from, and based upon Fairbairn's rule, the difference of properties possessed by cast-iron and wrought-iron being taken into account; whilst the essentially vital difference of environment due to fluctuations of temperature was absolutely overlooked and ignored by him—an oversight which completely deprived the amended formula of any little value it might otherwise have possessed.

Thirdly, in view of Dr. Morrow's inconsistency, it would be advisable to examine his theory. His theory of the office of the ribs and flanges would scarcely be taken seriously by practical men, since, followed to its logical conclusion, it led to the theorem that a structure might be vastly stronger than its weakest part. But Dr. Morrow had fallen into yet another error, opposite in one sense, but similar in another, and an error which all men might not so easily detect. Objecting to the logarithmic rule, he (Dr. Morrow) had remarked: "The strain . . is due to the normal compressive force, as well as to the circumferential stress; and it is only this latter part that can be divided into the stress q to obtain the modulus E."* Dr. Morrow appeared to forget several important considerations, whilst devoting undue attention to trifling matters. He forgot, for instance, (1) that the circumferential stress itself was but the effect of the normal compressive force; (2) that the normal compressive forces on the tubbing afforded mutual lateral support to each other; (3) that this very lateral support was itself the great safeguard against collapse; (4) that his recognition of the "normal compressive force" was absolutely inconsistent with his faith in the great bugbear of collapse of which Prof. Louis and himself were so afraid; (5) that provision against the principal stress of any given kind coincidently provided against all minor stresses of the same kind; (6) that Dr. Morrow himself was committed to the principle now stated, since he had admitted that the stress due to the weight of the tubbing might be neglected, even if it amounted to 5,000 pounds per square inch.† And, finally, Dr. Morrow had quite overlooked the prac-

* *Trans. Inst. M. E.*, 1907, vol. xxxiv., page 111. † *Ibid.*, page 121.

tical proof of his error furnished by the significant fact that the logarithmic formula, leaving those minor stresses out of account, gave results absolutely as safe as his so-called "accurate" formula, which presumably took them into account, since Dr. Morrow approved of it. If Dr. Morrow's objections were worth anything at all, he should be easily able to show a conceivable tubbing case where the hyperbolic rule would fail and where, at the same time, his so-called "accurate" formula would succeed. He (Mr. Halbaum) would be pleased if Dr. Morrow would state such a case, practical or theoretical. The latter had already found it "inadvisable" to reply to his (Mr. Halbaum's) arguments,* and if he would find it equally "inadvisable" to answer the other questions now put, the members no doubt would be able to interpret that attitude as it deserved.

But Dr. Morrow had further remarked that: "the statement . . . . that the circumferential strains depend on the corresponding circumferential stresses only, is also erroneous."† He (Mr. Halbaum) had, as a matter of fact, never made that specific statement, but he was willing to accept it, and to defend it against the Doctor's *ipse dixit*. Dr. Morrow's criticism was either a mere nibbling at trifles, or else a direct attack on Hooke's law of strains. If the former, it was not worth troubling about; if the latter, it was more important, although it was still easily answered. It was probably a fact that during the last few years some men had decried Hooke's law. But the latest researches had shown that attitude to be wrong, so far as ordinary practical work was concerned. Probably Dr. Morrow was partial to Continental philosophy, and it would be of interest to quote Continental authority on the matter. M. Lucien Poincaré, Inspector-General of Public Instruction, had just written a most valuable epitome of present-day views on such matters,‡ and the following remarks were quoted from the authorized English translation:—§

"The purity of the note emitted by a sound has been often invoked as a proof of the perfect isochronism of the oscillation, and consequently, as a demonstration *a posteriori* of the correctness of the early law of Hooke governing elastic deformations. This law has, however, during some years been

* *Trans. Inst. M. E.*, 1908, vol. xxxv., page 69.

† *Ibid.*, 1907, vol. xxxiv., page 112.

‡ *La Physique Moderne, son Evolution.*

§ *The New Physics*, 1907, pages 135-136.

frequently disputed. Certain mechanicians or physicists freely admit (*sic*) it to be incorrect, especially as regards extremely weak deformations. According to a theory in some favour, especially in Germany, that is, the theory of Bach, the law which connects the elastic deformations with the efforts would be an exponential one. Recent experiments, however, by Professors Kohlrausch and Grüneisen, executed under varied and precise conditions on brass, cast-iron, slate, and wrought-iron do not appear to confirm Bach's law. Nothing, in point of fact, authorizes the rejection of the law of Hooke, which presents itself as the most natural and most simple approximation to reality."

The above quotation, coming from a high Continental authority, would doubtless be appreciated by practical men, even if Dr. Morrow should find in it yet another case which it was "inadvisable" that he should answer.

Fourthly, attention might be called to Dr. Morrow's so-called facts. He had attempted to ride down part of his (Mr. Halbaum's) opposition by the statement that Sir John Anderson had not said "anything so absurd" as that surplus material in a structure was a source of weakness.* Of course, every engineer knew that Sir John was referring to redundancy. But the question as to whether or not he made the statement quoted was easily disposed of. Sir John's own words were as under:—

"In designing machines or structures, not only is there a correct form, but it is of the greatest importance that that form should not be departed from unnecessarily. The correct form is that in which every part is proportioned to the straining action to which it is subjected, so that the stress reaches the same maximum limit on every section. If, instead of being thus proportioned, a structure has a surplus of material in some parts, that surplus may not only not strengthen it but may positively weaken it, and may render parts, otherwise of sufficient strength, incapable of sustaining the load for which they have been calculated. Thus, for example, a chain with one link smaller than the others . . . is reduced in strength, not only in proportion to the reduction of section at the weak point, but in a still greater degree. In consequence of the surplus resistance in the other parts, most of the elastic work will be concentrated on the weak link. . . . . Although, strictly speaking, we cannot increase the strength of a structure by securing equality of sectional area, because the strength still remains dependent on the weakest section, yet virtually we increase the strength, by preventing the gradual deterioration of the resistance at one point, and thus diminishing the risk of fracture."†

The above deliverance of Sir John Anderson shattered the entire Morrovian philosophy, and utterly demolished the Doctor's theory that the great sources of strength in the tubbing lay

* *Trans. Inst. M. E.*, 1908, vol. xxxv., page 69.

† *The Strength of Materials*, by Sir John Anderson, eleventh edition, 1892, pages 155-156.

in the ribs and flanges. Sir John Anderson—an indubitable authority in such matters—therein emphasized the principle that the structure was limited in strength by the weakest section or member. And, hence, he coincidently emphasized the fact that the strength of tubbing for all shafts, deep or otherwise, was limited by the thickness of the shell. At all events, the above quotation proved that Sir John Anderson had really made the statement which Dr. Morrow had pronounced "absurd" and the publication of which the Doctor had denied. There was, however, nothing absurd about Sir John's statement, as it simply affirmed that a surplus resistance in parts of a structure had pretty much the same effect as a surplus temperature in parts—a fact which any engineer with some little knowledge of physics might readily foresee. It had already been pointed out that, in attempting to equate Fairbairn's formula to the tubbing problem, Dr. Morrow had altogether overlooked the factor of differential temperatures. It now appeared that he had further overlooked the factor of differential resistances due to redundancy of material; and not only so, but he had denied that such differential resistances could obtain, and had characterized the principle so clearly explained by Sir John Anderson as absurd.

Fifthly, with regard to Dr. Morrow's actual results in the shape of formulæ, his "plate formula" was Prof. Unwin's rule; but since Dr. Morrow had proposed to apply it in a way that Unwin never contemplated, he had done wisely in withdrawing it, or, at least, in admitting that, so far as the tubbing case was concerned, it could only apply in special cases. With respect to his "accurate" formula marked (10*a*), it was practically the same as the logarithmic rule, as was well shown by the table contained in the writer's present contribution to the subject. Its chief fault as a tubbing rule was that it failed to call the attention of the engineer to the possibility of corrosion. As to his practical formula marked (11), it would answer so far as the pressure-part of a rational tubbing formula was concerned, but it gave no warning against corrosion. With regard to his formula marked (24), it was based on Fairbairn's rule, which the Doctor himself condemned, and even then was wrongly deduced. Any careful comparison of the differential factors in the two cases would show that there was no ordinary design of

tubbing that was not already sufficiently secure against collapse, and the formula referred to was merely a grotesque result of the collapse-scare recently raised, first in a mild form by Mr. Charles Pilkington and then in the acute form by Prof. Louis and Dr. Morrow. In his (Mr. Halbaum's) opinion, the supposed collapse-risk might be dismissed from their minds as a sheer bogey, so long as the ordinary designs of tubbing were adhered to.

Coming to Dr. Morrow's "ring-formula," its consideration demanded a little more space. First of all, let them clearly recognize that it was a collapse-formula, and a formula which assumed that the collapsing pressure increased as the cube of the thickness. But Prof. W. C. Unwin, whose authority was world-wide, had said:—"In particular it is clear from the experiments that the collapsing pressure does not increase quite so fast as t^3."* However that might be, one thing was perfectly clear, namely, that this collapse-formula was out of joint with the whole problem, seeing that the collapse-idea itself was quite opposed to all practical experience. For example, Mr. Frank Coulson, whose wide experience of such matters was well known, had remarked that: "It seemed to be taken for granted that cast-iron tubbing 2 inches thick would be twice as strong as cast-iron tubbing 1 inch thick, but this did not work out in practice."† He (Mr. Halbaum) would pause a moment to consider why that was so, and he would suggest that tubbing doubly thick was less than doubly strong, for the following reasons:—(1) Because the tubbing cylinder was subject to the law of all cylinders as that was illustrated in the hyperbolic formula for the thickness. (2) Because the redundant material in the thicker tubbing was a greater proportion, and the law laid down by Sir John Anderson was thus more flagrantly violated than in the case of the thinner tubbing. (3) Because (repeating the above in other words) the ordinary tubbing case furnished a problem of crushing forces much more conspicuously than it furnished any real problem of provision against collapse. That was his (Mr. Halbaum's) theory of the case; it agreed altogether with Mr. Coulson's experience that tubbing doubly thick was never found doubly strong; and it explained how futile it was for

* *The Elements of Machine Design*, thirteenth edition, 1892, vol. i., page 84.

† *Trans. Inst. M. E.*, 1908, vol. xxxv., page 48.

Dr. Morrow to come forward with a ring-formula proceeding on the absurd assumption that tubbing doubly thick would be eight times as strong!

The main difficulty of the tubbing problem was not connected with collapse at all. Could Dr. Morrow and Prof. Louis cite half-a-dozen clear cases of collapse from the entire history of mining throughout the world? The main difficulty was not even provision against crushing force: the great case for investigation was that of the corrosive properties and powers of the various mine-waters. As Mr. T. Campbell Futers had manfully said: "the only objection that could be brought against the tubbing of the 'grand old engineers' was not that it was not strong enough, but that they had underestimated the length of time that the tubbing was required to last. He had not heard of a single instance where tubbing had failed owing to a want of sufficient strength to resist the pressure of the hydrostatic head of water."* The element of time alluded to by Mr. Futers was inseparably connected with the corrosive energy of the shaft-water, and therein was the real difficulty of the entire problem. He (Mr. Halbaum) ventured to express the earnest hope that members would not permit their attention to be distracted from that by any side issue. He had furnished a simple formula which would keep that phase of the question constantly before their eyes, and he ventured to state that neither Prof. Louis nor Dr. Morrow had been able to amend it in any single particular. They had emphasized an imaginary collapse-risk which had no real existence; they had objected to the pressure-member of his formula without being able to improve on it in any possible detail; but the one difficulty of the whole case they had left for others to tackle, namely, the difficulty of fixing the precise place of corrosion. It arose solely from the general lack of reliable data, and he (Mr. Halbaum) would conclude by simply repeating the request preferred in his paper—that mining engineers would set about in genuine earnest to collect, record, and compare the data desiderated.

Mr. Arthur Ross' paper on "Circulation and Heat Absorption in Steam Boilers" was read as follows:—

* *Trans. Inst. M. E.*, 1907, vol. xxxiii., pages 619-620.

CIRCULATION AND HEAT ABSORPTION IN STEAM BOILERS.

By ARTHUR ROSS.

About twelve to fifteen years ago, a great deal of important work was done and results published upon the rate of heat transference from fire to water in a steam generator. Since that time the subject appears to have been practically dormant, and the interest then aroused has considerably abated. At the time when most of these investigations were made water-tube boilers, the Belleville in particular, were forcing themselves upon the attention of boiler users. Although that question is not now so acute, yet it cannot be denied that the subject of water circulation is still one of great importance, seeing that working pressures are daily increasing, more intense fires are required, and fuel is dearer.

The ideal conditions are represented by the complete absorption in the boiler-water of all heat generated by the fuel. That we can only approximate to such perfection is common knowledge, but the aim of every efficient engineer is to reduce to a minimum the gap between ideal and actual.

One of the most certain helps to this end is to ensure a frequent change of water in contact with the heating surface, or, in other words, a first-class circulation. The reason for this is obvious, when the non-conducting power of water is remembered. The late Lord Kelvin gave the thermal conductivity of iron as 80 times, and copper as 500 times, that of water. The thermal conductivity of iron was given as 3,500 times, and copper as 20,000 times that of air, so that the thermal conductivity of water is over 40 times that of air. For the purpose of comparison, we can take air as equivalent to steam, and consider steam 40 times a worse conductor of heat than water, or 120 times worse than iron. Thus it is clearly advantageous to keep water always in contact with the heating surfaces, as steam taking 40 times as long to absorb the same quantity of heat as iron results in too much heat being stored in the iron tube or plate, with disastrous

results in every instance. Several experimenters have shown that an enormous evaporation per square foot can be obtained with perfect safety, provided that water is always in contact with the metal, from 50 to 100 pounds per square foot per hour having been actually obtained.

Reference was made by the author to Mr. C. W. Williams' work on *The Combustion of Coal and the Prevention of Smoke Chemically and Practically Considered*, published in 1854, the early days of steam navigation, and when the wellknown type of "Scotch" marine boiler was being evolved, but not yet produced. In these early types, large flat surfaces with narrow water-spaces were common, but these boilers continually failed. The failure of these plates was put down to slackness of circulation, resulting in a film of steam adhering to the plates, which prevented the heat from being absorbed quickly enough by the water, overheated and bulged plates being the result. It must be evident that under such circumstances of overheating the heat does not travel through the plate three or five times as fast as before, although the water is boiling, but becomes stored in the plate. One paragraph of this most interesting book is a quotation from Mr. Robert Murray's *Treatise on the Marine Engine*, which states that: "It is a point of the utmost importance that no part of the heating surface of a boiler should be so situated that the steam may not readily rise from it and escape to the surface; since the plate, if left in contact with steam instead of water, becomes unduly heated and destroyed."*

Mr. Williams gives the following table, containing the result of numerous experiments:—†

Nature of the Recipient.	Heat received by the plate in given times.	Portion of the heat transmitted by the plate.	Portion of the heat remaining in the plate.
	Degrees.	Degrees.	Degrees.
Water	1,000	1,000	*Nil*
Water and Steam	1,000	800	200
Steam	1,000	600	400
Air	1,000	400	600

* *The Combustion of Coal and the Prevention of Smoke Chemically and Practically Considered*, by Mr. C. W. Williams, 1854, page 155.

† *Ibid., page* 164.

Although these figures would not go unquestioned to-day, yet they are instructive as showing that circulation was being considered an important question in those early days of boiler construction.

The Engineer of February 28th, 1908, contains, among other matter important to boiler-users, a leading article on "Maximum Evaporation," in which it is stated that: "The great danger lies in the formation of steam between the water and the plate which remains there. For this reason a rapid circulation should be maintained in order that the steam may be swept away as fast as it is formed."*

Notwithstanding these results, there is still to be overcome the reluctance of water to absorb heat rapidly, resulting in a considerable range of temperatures existing in different parts of even a small vessel; how much greater, therefore, are those differences in a large bulk like a steam boiler, with a maximum temperature many times that of the atmosphere.

It is undoubtedly true that convection currents in fluids assist in the absorption of heat by setting up movements due to the differences in gravity of the warmer particles, but these currents stop when ebullition is general, all movement then being upwards; and these currents, being a natural circulation, support the writer's contention as to the value of circulation, their great drawback being that they cease to operate when boiling is in full swing. Further, convection currents are only above the source of heat, therefore do not operate below the fire-bar level of a Lancashire or similar boiler, so that it is not surprising to find great differences of temperature above and below the furnaces.

Recent experiments made on a dry-back boiler gave the results contained in the annexed table, showing how the temperature of the water at the bottom of the boiler rose hour by hour after fires had been lighted. The steam pressure of the boiler when at work is 160 pounds per square inch, with a temperature of between 360° and 370° Fahr., so that the last readings taken after the boiler had been on load for some hours was about 140° Fahr. colder at the bottom than at the top.

Mr. Rankin Kennedy, to illustrate the poor conductivity of water downward, states that if "water were kept boiling at the

* *The Engineer*, 1908, vol. cv., page 222.

surface, the heat would not penetrate sufficiently to begin melting ice at a depth of 3 inches in less than about two hours."*

Time.	Temperature. Degrees Fahr.	Pressure per square inch. Pounds.	Time.	Temperature. Degrees Fahr.	Pressure per square inch. Pounds.
a.m.			a.m.		
9·0	60	—	3·0	83	15
10·0	60		4·0	83	15
11·0	62		5·0	83	15
12·0	68	—	6·0	83	15
p.m.			7·0	90	20
1·0	69	—	8·0	92	20
2·0	69	—	9·0	92	25
3·0	70	—	10·0	92	40
4·0	73	10	11·0	97	70
5·0	75	15	12·0	103	105
6·0	76	15	p.m.		
7·0	78	15	1·30	125	140*
8·0	79	15	2·30	166	160
9·0	79	15	3·30	223	160
10·0	79	15	4·30	225	160
11·0	80	15	5·30	224	160
12·0	82	15	6·30	224	160
a.m.			7·30	224	165
1·0	82	15	8·30	224	160
2·0	83	15	9·30	224	160

* Boiler on load at 1·50 p.m.

Some interesting experiments were carried out by Mr. Lavington E. Fletcher, chief engineer to the Manchester Steam Users' Association, to which the author would direct the attention of the members.†

That the writer is not singular in emphasizing this subject is shown by the following extracts out of many. In 1874, Prof. Osborne Reynolds communicated a paper to the Literary and Philosophical Society of Manchester, in which he remarks that:

"There is one assumption which upon the face of it seems to be contrary to general experience, this is, that the quantity of heat imparted by a given extent of surface to the adjacent fluid is independent of the motion of that fluid or of the nature of the surface; whereas the cooling effect of a wind compared with still air is so evident that it must cast doubt upon the truth of any hypothesis which does not take it into account."

"The heat carried off by air or any fluid from a surface, apart from the effect of radiation, is proportional to the internal diffusion of the fluid at and near the surface."‡

At a recent enquiry into the explosion of a live-steam feed-heater drum, Mr. — Carlton, Board of Trade Engineer Surveyor, reported, as one of the causes of the explosion, "the severe strain-

* *Modern Engines and Power Generators*, by Prof. Rankin Kennedy, 1904, vol. iv., pages 9-10.

† *Report on a series of Red-hot Furnace Crown Experiments, to ascertain the Result of Injecting the Feed-water into a Boiler when short of Water and with Fires Burning*, by Mr. Lavington E. Fletcher, 1889.

‡ "On the Extent and Action of the Heating Surface for Steam Boilers," by Prof. Osborne Reynolds, *Proceedings of the Literary and Philosophical Society of Manchester*, 1874, vol. xiv., page 8.

ing of the plates due to the somewhat large variations of temperature that exist in these drums owing to water in the drum being frequently cooler below the surface than the steam, and causing the bottom of the drum to be colder than the top."*

It may be suggested that so long as the heat is absorbed it does not matter whether it comes from furnace-plate or shell-plate, but when the enormous expansion possible between the extreme temperature is noted, the importance of rapidly distributing the heat all over the boiler will be recognized.

Taking, for instance, an ordinary Lancashire boiler, the heat is excessive at the bridge, probably between 2,500° and 3,000° Fahr., while the temperature of the gases at the last damper may not exceed 500° Fahr., a difference of about 2,500° Fahr., occurring in the length of a single unit. Taking the co-efficient of expansion of steel as 0·00000672 for 1° Fahr., and assuming that the furnaces were at the maximum temperature throughout, as also that the shell was at the minimum temperature throughout, the difference in lineal expansion would be 6·048 inches in a 30-foot boiler. That it is not likely that such severe conditions occur in practice the writer is aware, but they do occur in a modified form in every boiler, explaining the reason for leaky seams and weeping rivets on end-plates. It also emphasizes two other important facts, one, the necessity for rapidly absorbing the intense heat at the furnace and distributing it to colder parts; the other, the importance of preventing any obstruction to the free passage of heat through the plate by accumulations of scale or grease. If these obstructions have accumulated on the plates, then the heat will become stored up in the plate or tube, bringing about the extreme expansion and destruction of the boiler.

Supposing for a moment that the furnace-tube was so secured at the ends that the top and bottom of the tube could be kept at the same length, when heated, the top would have to be compressed and the bottom stretched. Every difference of 1° Fahr. would produce a compressive stress in the top and a tensile stress in the bottom of 93 pounds per square inch.

With regard to the shell, there is not quite the same frequency of movement as in the furnace, as a result of opening the door; but there is no doubt about the magnitude of the stress produced on plates and joints.

* *The Engineer*, 1908, vol. cv., page 82.

More equal distribution of the heat is becoming more and more recognized as a most important feature, so far as the life and safety of the boiler is concerned; but another valuable detail is that by the effort to distribute the heat more equally, a circulation is set up which induces a more rapid absorption of heat by the water.

The writer does not propose to take more than a cursory survey of some of the classical work done on the subject. Mr. G. A. Hagemann was one of the first to determine accurately the influence of speed on cooling or heat absorption. Other workers as far back as the latter part of the seventeenth century, including Sir Isaac Newton, had preceded him in investigating the question of heat transmission; but so far as the writer has searched for the purpose of this paper, Mr. Hagemann was the first to study with exactness the effect of circulation. Mr. Hagemann's experiments may be divided into three sections, namely:—

(1) To determine the influence which speed of flow had upon transmission when the temperature differences were kept constant; increased flow resulted in greater absorption.

From the figures and curve given by Mr. Hagemann it will be noticed that with no flow at all, the temperature was considerable (due to convection currents), and the whole curve clearly proves that increased flow meant increased absorption, when the available heat was kept constant.

(2) To find the influence of temperature differences at constant speed. The figures and curves clearly show that, by increasing the available heat at constant speed, the efficiency is lowered.

(3) The influence of water speed on heat transmission. The figures and curves show that as speed increases, efficiency also rises.

With reference to the curves, Mr. Hagemann remarks that: "It is a natural result of the method of experiment adopted that the parts of the curves of transmission actually determined are not greater, and begin rather high up, but the principal result obtained previously, namely, that the transmission of heat increases with increasing speed, is further confirmed."*

* "Experiments on the Transmission of Heat," by Mr. Gustav Adolph Hagemann, *Minutes of Proceedings of The Institution of Civil Engineers*, 1884, vol. lxxvii., page 320.

Another most striking set of experiments were those of Prof. — Ser, of the College of Arts and Manufactures, Paris, his investigations being also to determine the effect of velocity upon heat transmission. The temperature of the heating medium (steam) being kept constant, the effect of different velocities of the water upon the rate of heat transmission is shown in the table and curve contained in his paper, and confirms Mr. Hagemann's results.

Prof. Ser's apparatus was clearly not suitable for experiments with temperatures sufficiently high to produce steam in the circulating water, so that his remark that "the transmission of heat for the same difference of temperature is more than tripled when the liquid is boiling, which is due to the greater speed in the circulation of the heated liquid,"* is only a surmise, and we now known from the later experiments of Mr. G. Halliday that this is not the case, but rather that steam bubbles act as worse conductors of heat than solid water, so reducing efficiency.†

It is unfortunate that further work was not done on the lines laid down by Mr. Halliday, as his apparatus enabled steam to be formed in the circulating water. His experiments demonstrated that the efficiency fell when the steam mixed with the water, and he further proved that there is a critical speed, which, if exceeded, will also lower efficiency, tending to show that the water must be in contact with the source of heat for an appreciable time to absorb its share. After that point of speed is reached, it seems to slip over the surfaces before full heat absorption takes place; but the writer is not certain whether this will apply to boilers where the water returns to the source of heat, although this was no doubt true of Mr. Halliday's apparatus.

Some experiments of great interest were carried out by Mr. J. Hirsch to discover the rate of evaporation in the part of a boiler most exposed to the fire; and he obtained results of from 21 to 50 pounds per square foot of the heating surface. His other experiments were also very valuable, as he made a special study of the effect of scale, oil, and grease, upon the conductivity of the heating surfaces. The inside of his apparatus was coated with a layer of plaster $\frac{1}{25}$ inch thick, and he found that an evaporation of

* *Traité de Physique Industrielle*, 1887-1891.

† *Transactions of the Institute of Marine Engineers*, 1899-1900, vol. xi., Paper No. 84.

39 pounds per square foot of surface per hour resulted in a temperature difference of about 86° Fahr. higher than when distilled water was used in direct contact with the plate. With a layer $\frac{3}{16}$ inch thick, a 30-pound rate of evaporation caused the external temperature of the plate to rise above 482° Fahr., a difference of about 75° Fahr. as compared with distilled water; and to evaporate 40 pounds, it exceeded 732° Fahr., or 410° Fahr. above the results with distilled water. He also covered the inner space of a boiler with mineral oil, wiping nearly all off and leaving only a thin layer. It was found that the heat in the plate increased considerably, the water side of the plate giving a higher result; and when a moderate evaporation of 35 pounds per square foot per hour was made, all the fusible plugs melted, proving a temperature above 842° Fahr. Further experiments were made with small tin saucepans, which became red-hot at low temperatures when a coating of grease adhered and burnt to the surface. Mr. Hirsch states that:

"He had observed that where an abnormal elevation of temperature was attained in the experiments, black patches, apparently arising from the partial decomposition of fatty matter, adhered to the boiler at the beginning of the trial, not having been completely removed by the cleansing. Wishing to discover if they had any influence on the phenomena of the transmission of heat, he greased a clean tinned saucepan with mineral lubricating oil and heated it without water over a slow fire to decompose the fatty matter. The bottom of the saucepan was found to be covered with a black coating to which water would not adhere. The saucepan was then filled with water, and heated over the furnace. After boiling a minute one part at the bottom of the saucepan was seen to become red-hot, and the incandescence soon spread over the rest of the area covering the opening of the furnace. Evidently the bottom of the saucepan was never wetted, and the water assumed the spheroidal condition. Even if the grease was confined to a limited portion of the bottom, that part alone became incandescent at first, but the red heat gradually extended over all the surface exposed to the fire. This experiment was repeated several times with different intensities of fire. With heat corresponding to an evaporation of about 54 pounds per hour per square foot of heating surface, the colour of the bottom was bright orange, but when 30 pounds were evaporated, the colour was dark cherry."

"Further experiments shewed the following results:—If a perfectly clean tinned iron saucepan is used, however intense the flame, the water boils in the usual way, and the tin is not melted. The surface is not affected by the heat when the tinning has been removed by scraping or by oxidation, either by the action of humid air or by that of ammonia or hydrochloric acid. In either state of the surface a thin layer of mineral oil, applied cold, does not interfere with regular ebullition. But if the oil is previously decomposed by heat, or if an oily rag is laid on the bottom of the saucepan and held there by a weight, overheating immediately takes place. The same effect is produced if a solution of salt is evaporated in an oxidized saucepan, and the

bottom when covered with a thin crust of salt, is smeared with cold mineral oil. The smallest quantity of linseed oil at the bottom of the saucepan immediately produced overheating even with the low temperature of evaporation of 20 to 24 pounds. Spirits of turpentine and oil of turpentine did not produce overheating unless mixed with a small quantity of linseed oil. A mastic of red lead easily produced overheating, but not so quickly with colza oil as with linseed oil. Valveline, when laid on cold, only caused a dangerous glow when the heat was very intense—equivalent to a 70 pounds evaporation."*

With these results the writer considers that sufficient evidence has been given to prove that circulation is valuable, also that plates as well as tubes exposed to fire should be clear of scale and grease.

There is an indisputable unanimity in the results obtained by all these experiments and those of others whose work cannot be referred to specifically, and they all unite in showing:

(1) That circulation increases heat absorption.

(2) That steam mixing with water spoils the rate of heat absorption in proportion to the amount of steam present, in accordance with Mr. Halliday's experiments.

(3) That the detrimental effect of scale upon heat absorption, and the destructive effect liable if oil accumulates and adheres to the surfaces, are demonstrated by Mr. Hirsch's experiments. The first points to a better output of steam per unit of fuel; the second that circulation to be most useful and fully effective should be of solid water, not mixed steam and water; and the third that the removal of solids also helps to increase the steam output, whilst the removal of oil is shown to be an absolute necessity.

Having proved the point as to the value of circulation, it will be interesting to see how the matter has been dealt with in practice. There is no doubt that the recognition of the value of circulation is to some extent responsible for the extraordinary designs of many tubular boilers. Numerous attempts have also been made to obtain this desirable effect by cross-tubes in furnaces, by bent tubes, rings, etc., in the furnace gases, but they all fail because when steam is formed the solid column of water in them is broken, and circulation is stopped. Various types of baffles have been tried, but they fail because no baffling will turn steam or steam-hot water downwards when it has a free choice to go upwards.

* *Bulletin de la Société d'Encouragement pour l'Industrie Nationale*, 1890, vol. v., page 302; also abstract in *Minutes of Proceedings of the Institution of Civil Engineers*, 1892, vol. cviii., page 464.

Some engineers claim to set up a circulation by the connection at the internal end of the feed-pipe of a nozzle or series of trays, but the impossibility of these assisting to any extent is apparent when the discharge is only equivalent to the rate of steam production, the majority of the incoming water generally becoming steam immediately on discharge, whilst the outflow of the rest is mere subsidence. There is no fireman's hose effect as some imagine.

One inventor (Mr. H. W. Harman), in 1859, patented a propeller fitted at the bottom of the back-end of a boiler and actuated by a shaft passing through the top of the boiler-shell. *

The good features of a perfect circulator are:—(1) That it shall not require outside power to drive it, like Mr. Harman's propeller, but be fully automatic; (2) that it shall start practically as soon as the fires are lit; (3) that it shall always circulate solid water, whatever the heat and pressure of the boiler may be; and (4) that it shall work when fires are banked and the boiler standing until quite cold.

All these good features are present in the "Hotchkiss" automatic circulator,† while to its circulating powers are added the following advantages:—

(5) Deposit, oil, and grease are collected and removed continuously from the boiler while at work; (6) priming is prevented; and (7) by the better expansion of the boiler, repairs are obviated and the life of the boiler is considerably lengthened.

The "Hotchkiss" commences work quite automatically when the water under the funnel is raised about 20° Fahr. The movement is at first slow, but rapidly gains in speed, the maximum being reached before steam is made. Being removed from any heating surface, solid water is always circulating whatever the pressure. By taking the hot water from over the fire and delivering it along the bottom of the boiler, the usual course is reversed; and on leaving the return-pipe the hot-water follows its natural law and rises. This movement continues during the whole time that the boiler is at work or even hot, only stopping completely when the boiler is cold again.

* British patent, 1859, No. 1,909.

† "The Circulation of Water in Steam-boilers," by Mr. Arthur Ross, *Trans. Inst. M. E.*, 1905, vol. xxix., page 618.

Its power of collecting mud, oil, etc., is apparent each time that it is blown out, tons of mud having been collected from a single boiler after six and eights weeks' working.

At the conclusion of the paper, Mr. Ross conducted a very interesting series of experiments, by means of transparent models of boilers, to demonstrate the theories put forward in the paper.

Mr. A. L. Steavenson (Durham) congratulated the writer of the paper, but he considered that the Hotchkiss apparatus was rather complicated and that the parts were liable to go wrong and give trouble in working. The writer did not seem to recognize the fact that the days of boilers were over, and that, owing to the utilization of rivers and water-falls, coal would soon become a drug in the market.

Mr. C. C. Leach (Seghill) said that he had not found that the old Lancashire boiler, without a good circulation, would be rapidly destroyed. He had had four of them in use for from twelve to fifteen years, without any patent apparatus on them at all. The water used was not particularly good, and the only repairs had been one rivet amongst the four boilers. If properly built, the Lancashire boiler gave the least trouble of any kind of boiler about a pit. The old egg-ended boiler was always out of repair. One thing against the Lancashire boiler was the dead water at the bottom, but that gave no trouble at all, and the economy was nearly equal to any tube boiler.

Mr. J. A. G. Ross (Newcastle-upon-Tyne) said that he was rather surprised to hear the writer speak of the inefficiency of tubes. Those close behind the firebars were liable to be burned out, but he had known boilers to give good results by having tubes put in. At the same time, the method illustrated by the model was excellent; it afforded a means not only of circulating the water but of collecting the mud at the top without opening the boiler, which was a very good thing indeed. With regard to the writer's remarks about the expansion of the boiler, he thought that he was hardly correct. The difference of 2,500° in temperature between one end of the boiler and the other was no doubt in the flame and not in the iron, and the

inference was that the boiler would expand 7 inches, but this was not so; he did not suppose that a boiler 30 feet long would under such circumstances expand an inch. If they had a temperature of 2,500°, it would melt the iron. He thought the apparatus very good provided that it was taken care of.

Mr. W. C. Blackett (Sacriston) asked the author whether he was able to give them any information as to what would be the comparative effect in the coursing of heat through the flues of the boilers. Taking the case of a boiler on coke-ovens, where they could either take all the heat from the flues at once, or, if they chose to do so, take it and course it in the ordinary way: which would be the most likely to give the best results, leaving out the question of the retarding effects due to friction?

Mr. Arthur Ross said that, with regard to the value of circulation in preventing unequal expansion, he could quote one instance which was very apposite. At the Royal Victoria Docks, London, there were five Lancashire boilers, which were condemned on account of the unequal expansion from which they suffered. The boiler-makers were always in the boiler-house, as before one was repaired another was ready to come down. These boilers were working 6 hours and stopped 6 in every 12 hours, pumping 3 up and 3 down tide, the docks not being level with the river. The boilers suffered terribly from unequal expansion, and some six or seven years ago it was decided to turn them out and try some other type. An opportunity was given of introducing the Hotchkiss apparatus, and as a consequence the old boilers were still there to-day, and would be good for at least other five years. The boilers were clean, and it was only a question of unequal expansion. This case was, of course, very exceptional, as they probably would not find another set working 6 hours and stopping 6.

Mr. C. C. Leach remarked that colliery boilers usually did so.

Mr. Arthur Ross, continuing, said that in the case which he had mentioned the boilers had to be ready to be called upon with very little loss of time. With regard to cross-pipes, he had no doubt that a great deal of steam was made in them; but they were originally put in as circulators, and they did circulate while the

water kept solid, but immediately steam was made the water became froth, and there was no further circulation. Supposing that the Hotchkiss was made to circulate from the bottom upwards, no economical result was obtained. With regard to temperatures, he had, of course, quoted an exaggerated case, and was presuming that the heat was absorbed in the metal and that the two extremes of temperature were present. It was to prevent the heat from being absorbed in the metal that circulation was of great assistance, but the example used was only an illustration of extremes. In practice it did not take place to such an extent; the probability was that the expansion of a 30-foot boiler was less than 1 inch; but, if they tried to push the end-plates out even $\frac{1}{2}$ inch, they would have to be very elastic. With regard to the absorption of heat in gas-fired boilers, whether it was best sent through flues or made to travel round the sides, he would not like to form an opinion without further experiments himself. His own experiments were still incomplete, but he hoped to finish them during the forthcoming winter. The question which really arose in the building of boilers was not the total heating surface but the effective heating surface. There was such a thing, however, as having the gases too cool, and in going through the last flue they might be actually extracting heat from the boiler. They must have a big difference between the temperature of the gases and that of the water to secure effective transference of heat.

Mr. W. C. Blackett presumed, therefore, that Mr. Ross condemned the plan of having the side-flues of such a height that they got above the water-line in the Lancashire boiler.

Mr. Ross said that the gases would always keep at the highest point of the flue. This might tend to a superheating action upon the steam; but, in the presence of so large a bulk of water, the tendency would most likely be to evaporate more water. As already pointed out, however, steam being a worse conductor of heat than water would act to some extent as an insulator between the plate and the water, so that there was every probability of the upper plates, exposed to high-temperature gases, being much hotter than the lower ones, thus causing unequal expansion. Where flame or high-temperature gases touched the plates, water should always be on the other side. This action was well illustrated by a steam-filled tube on a water-tube boiler

which was being pressed: the rapid generation of steam blew the water out at both ends simultaneously, circulation was stopped, and often a frequent repetition caused failure of the tube by softening or withdrawal of the end from the drum. Too much heat became stored in the metal.

The PRESIDENT (Mr. John H. Merivale) proposed a hearty vote of thanks to Mr. Ross for his very practical paper, and also for the great trouble that he had taken to illustrate it with such interesting and effective apparatus. He did not agree with Mr. Steavenson that we should be able to do without boilers and that coal would soon become a drug on the market. He held a strong opinion that the result of introducing any new invention or the use of any new substance which at first sight seemed likely to supersede the use of some other, really had the opposite effect, as those who were foolish enough to sell their gas shares twenty years ago, when electric light was coming into use, knew to their cost. Boiler improvements tended to safety and to lessened consumption of fuel, and the smaller the consumption of fuel was, the larger was the demand. This was another theory that he held, and, of course, their interests were bound up in there being a demand for coal.

Mr. C. C. LEACH seconded the vote of thanks.

Mr. Ross briefly acknowledged the vote.

APPENDICES.

I.—NOTES OF PAPERS ON THE WORKING OF MINES, METALLURGY, ETC., FROM THE TRANSACTIONS OF COLONIAL AND FOREIGN SOCIETIES AND COLONIAL AND FOREIGN PUBLICATIONS.

STANNIFEROUS AND AURIFEROUS DEPOSITS OF THE TRANSVAAL AND RHODESIA.

Einige Bemerkungen über afrikanische Erzlagerstätten. By R. Beck. *Zeitschrift für praktische Geologie*, 1906, *vol. xiv., pages* 205-209, *with* 2 *figures in the text.*

In the course of his journey through South Africa in 1905, as a guest of the British Association for the Advancement of Science, the author was able to amass a scientifically valuable and interesting collection of rock-specimens. The study of these has formed the main basis of the observations summarized in the present abstract.

The stanniferous deposits of Enkeldoorn in the Buschveldt, north of Pretoria, were discovered in April, 1904. The main lode strikes north-north-westward through the red Buschveldt Granite, which here, however, has lost much of its red coloration, and should rather be described as greyish-green. This porphyritic granite, so well-known for the remarkable micropegmatitic structure of its groundmass, has been shown to send apophyses into a hard splintery greenish-grey felsite, which crops out east of Enkeldoorn Spruit, a relationship which recalls the association in the Saxon Erzgebirge of the Zinnwald Granite with the older Teplitz Quartz-porphyry. On the other hand, a younger fine-grained granite sends apophyses into, and forms bosses amid, the Buschveldt Granite, and it is this younger granite which is the original ore-carrier.

The Vlaklaagte tin-ore deposits, a little way north-east of Enkeldoorn, and about 31 miles north-east of the Premier diamond-mine, show a still closer lithological resemblance with the Zinnwald rock-series. Corresponding to the Teplitz Quartz-porphyry is a felsite which occurs more especially in the western portion of the mining field; it is traversed by the red Buschveldt Granite, just as in the Erzgebirge the Teplitz Porphyry is invaded by the Zinnwald Granite. In both districts, the latest eruptives are fine to medium-grained grey granites. Microscopic investigation shows the complete independence of the younger granites from the older. At Vlaklaagte, as at Zinnwald, quartzose lodes of tin-ore occur in the younger granites, such as the junction-lode, 3¼ feet thick. Parallel with the lodes (again, just as in the Erzgebirge, and also as in Cornwall) run strips of greisen, about a foot wide, extremely rich in tinstone; this greisen, as usual, shows not a trace of the original felspars of the granite, and the author describes the results of a microscopic examination of the rock. A specimen of highly-decomposed Buschveldt Granite from Rooipoort proved to be impregnated with arsenical pyrites as well as granules of cassiterite. The author has also seen, and briefly describes, some very fine specimens of tin-ore from Swaziland.

The most interesting occurrence of gold in Rhodesia, from his point of view, is that of the Ayrshire mine in the Lomagunda district of Mashonaland. Here a hornblende-gneiss is worked containing native gold in the form of inclusions, the other chief mineral constituents being orthoclase, plagioclase, quartz, hornblende, and epidote, and more rarely ilmenite, titanite, biotite, magnetic pyrites, iron pyrites, and graphite. The workings have already been pushed down to a depth of 460 feet; but the proportion of gold, which in the upper levels (with secondary enrichment favoured by weathering) averaged 0·736 ounce per ton, at depths below 160 feet or so, has fallen to a quarter or half-and-ounce per ton. The ore-body has been proved for a length of about 1,500 feet, along the strike, and seems to be conformably intercalated among the steeply northward-dipping crystalline schists. It seems evident that the gold existed *in situ* before the metamorphism of the gneiss took place. In the year 1904, a rich auriferous conglomerate striking parallel with the Ayrshire deposit some 9 miles farther south was discovered, and traced over a length of more than 2¾ miles. The outcrop was in part worked out by the ancient miners. Occasionally magnetite and a little pyrites are found associated with the gold. At the Eldorado mine near the Hunyani river, where the auriferous banket averages 6 feet in thickness, the amount of gold per ton is 0·768 ounce. This rock bears no resemblance whatever to the well-known bankets of the Witwatersrand. The author lays stress on the abundance of carbonaceous particles in some of the gold-reefs of the Rand (as, for instance, in the hanging-wall leader of the Buckshot Reef), and by way of contrast gives a description of the cementing-material of the Tarkwa conglomerate of West Africa. L. L. B.

MINING DEVELOPMENTS IN THE GERMAN COLONIES.

Über geologische Untersuchungen und die Entwickelung des Bergbaues in den deutschen Schutzgebieten. *By* — Schmeisser. *Zeitschrift für praktische Geologie*, 1906, *vol. xiv., pages* 73-81.

Togoland.—A recently-discovered very pure Eocene limestone is being quarried and burnt for lime, which will obviate the necessity of paying such prices as £4 per ton for imported lime. At Toweya, a quartzitic sandstone, seamed with veins of chalcedony and quartz, carries a little gold. In the Banyeli district, a fine deposit of red hæmatite, some 40 feet thick, overlies a series of conglomerates, quartzites, arkoses, and shales with interbanded dolomites, which in their turn are underlain by an ancient ground-moraine of Permo-Carboniferous (?) age, full of striated boulders of foreign rocks. The iron-ore appears to be of metasomatic origin, the result of the action of ferruginous waters on a pre-existing limestone or dolomite. It is estimated that, by opencast working alone, 20,000,000 tons could be got from the principal deposit, and the ore is thought to be of very uniform character. Other deposits are known to occur to the west of that just mentioned. In the Lamatishi mountains an eruptive rock is found, with which are associated great blocks of titaniferous magnetite. In the clay-slates near the village of Kudyambo, inclusions of graphite, alternating with thin layers of quartz, are observed. About 10 miles south-west of Sokode, a metalliferous vein, 4 to 5 inches thick, crops out at a small waterfall on the Kendi; the gangue is chiefly quartz, mineralized with galena, chalcopyrite, and iron pyrites.

Cameroons.—About the end of 1904, mineral oil was struck at several points in the neighbourhood of the coast; but a bore-hole put down at Logobaba

attained the depth of 2,624 feet from the surface, and the younger marine sediments had not then been bottomed, nor had the oil-bearing strata proper been reached. Consequently it is still uncertain whether rich or even workable petroleum-deposits really occur in the colony. Concessions have been granted for mining tin-ores, an apparently rich deposit of these having been found in the Banyo district. Copper-ores are said to occur six days' journey south-east of Lau on the Benué.

German South-West Africa.—The great and rich copper-ore deposit at Otyisongati, near the headwaters of the Swakop, will form the object of active mining operations, so soon as peace has been re-established in that sorely-afflicted colony. Complete investigations as to the extension of the deposit in depth have not been practicable under the circumstances. A Swakopmund company is preparing to work another copper-ore deposit, that of Gorap. Immense deposits of a very beautiful marble occur at Etusis, but there is some question as to whether the tremolite-inclusions which it contains do not interfere sufficiently with its cohesion to prevent it from withstanding all the stresses and strains to which it would be necessarily exposed, if used widely as a building-material. The rebellion has prevented further exploration-work among the supposedly diamantiferous blue ground of the Gibeon district. For similar reasons, the investigations started by the German authorities, as to the water-supply and as to the debatable existence of a coal-field in the colony, cannot be pursued at present.

German East Africa.—Government geologists, primarily occupied in seeking sources of water-supply for the larger settlements and for the main caravan-routes, incidentally recorded the existence of industrially important mineral-deposits. On the Iramba plateau, which is built up in part of granite and in part of crystalline schists, several reefs of auriferous quartz occur, furnishing typical examples of secondary enrichment in the cementation-zone above the underground water-level. Astonishingly rich in gold at and near the outcrop, these reefs become rapidly poorer in depth: thus, samples of quartz and native gold from depths not exceeding 65 feet have yielded assays of 128 ounces or more per ton, while the sulphidic ores from depths of 130 feet or so will perhaps yield barely as many grains. In the Ikoma gold-field, some 60 miles south-east of Speke Bay on the Victoria Nyanza, two islands (as it were) of greenish hornblende-schist rise from amid a sea of gneiss. The easternmost of these is traversed by five parallel reefs of auriferous quartz; while the westernmost can only boast one such reef, but this is said to be of considerable thickness and extent, and may be expected to prove richer in depth than usual. The easterly reefs are from 2 to 3¼ feet thick, of no great extent, and in their general habit recall the Iramba facies. Similar reefs occur at Sargidi, 3 hours' journey by road north of Ikoma, and near Nassa, south-east of the Victoria Nyanza. The Zentral-Afrikanische Bergwerks Aktiengesellschaft has been formed to work the Ikoma reefs, among others. The company has found in the Ussongo district a cavernous, ironshot, auriferous breccia, estimated to yield about 1 ounce troy of gold per ton. With it is associated a quartzitic ferruginous sandstone, cropping out west of the caravan-road, and also containing a small percentage of gold. As to gold-dredging in the rivers or placer-deposits, the prospects do not appear very promising. It must be borne in mind that, generally speaking, the rivers in that region have a short course, and during most of the year carry but little water in them. They are not, therefore, adopted to the formation of alluvia on a considerable scale, with the single exception of the Moame.

A concession was obtained in 1903 (by a Berlin publisher) for the exclu-

sive working of deposits of precious and semi-precious stones in a district bordering on the middle and lower course of the Rovuma. Here had been found, in an earthy, weathered hornblende-gneiss, inclusions as big as a man's fist of an almandine-garnet rich in magnesia. The garnets occur in great quantity, and are of fine quality; and so they have already found a market. The investigations made as to the possibility or advisability of attempting to work the graphite of Likongo and Nambirambi, do not seem to have eventuated favourably. Mica-deposits occur in various districts, and, although not comparable with the best Indian occurrences of the kind, they are capable of yielding a marketable mica, which may ultimately compete with the North American mineral. The dusky greenish-brown coloration of the East African mica is rather a disadvantage, which militates against its utilization for lamp-chimneys, for example; but the mineral has been shown by experiment to be a better insulator than the American mica, although inferior (in that respect also) to the Indian mica. Radio-active uranium pitch-blende was found, in 1904, to occur at an altitude of about 6,500 feet above sea-level, in the form of blocks, on the western slope of Lukvangule mountain, in south-western Uluguru. Common salt is got in the Uwinga district; and in the dry season common soda evaporates out on the shores of a natron-lake near the boundary, in the Moshi district.

Kaiser Wilhelm-Land (New Guinea).—The existence of gold is undoubted in all the rivers that course through the district lying between the eastern boundary and Cape Longuerne. To judge from the finely-divided native gold deposited in the lower reaches of the Varia, that river must be very rich in its upper course, which is, however, in British territory. Investigation has been mainly directed to the Vivo river-alluvia, in the uppermost 3 to 6 feet of which gold occurs in flakes of a very ruddy hue, often filmed over with iron-oxide. The bed-rock, curiously enough, fails to yield any of the precious metal. The gold appears to have been swept out of fissures in the diorite, in the decomposition-products of which rock it occurs in small quantity even up to the summits of the hills, whence the heavy rains carry it down into the valleys. The Vivo placers would well repay working, as their average yield promises to be high in comparison with that of Australian placers; but the climatic conditions are trying. The gold has not been transported very far in any case, and the primary deposit may yet be discovered up in the hills; but, again, several miles of the upper course of the Vivo are within British territory. Native copper of remarkable purity occurs as the infilling of fissures and cavities in the Kabenau basalt. Coal has been found in the Nusa valley, comparable in many respects with a Bochum gas-coal, but yielding a great deal of ash and containing much hygroscopic water. On distillation, it yields 57·5 per cent. of pulverulent coke.

Kiaochau.—Anthracitic coal has been proved on the island of Shui-ling-shan (Tolo-san) within the leased area, but it appears very doubtful whether the deposit will repay working. In the hinterland (which our German friends unquestionably extend to the entire province of Shantung), a German company is now at work in the Weihsien coal-field, near Fangtse, on three coal-seams, the uppermost of which averages 10 feet in thickness, the middle one 13 feet (yielding gas-coal), while the lowermost varies from 3¼ to 16 feet or more in thickness. The thickness and quality of the middle seam are affected in places by porphyrite-intrusions. The output for the year 1904 amounted to 84,887 tons, and for the first six months of 1905 it had already reached a total of 69,815 tons. A modern sorting-plant delivers big coal and nuts for the use of the railway and various factories at Tsingtau, while the smalls

and the duff are eagerly purchased by the Chinese. But the washing-plant and briquette-factory now being erected will use up even those residues.

In the Heishan basin, the coal-seams are generally thinner, few exceeding a thickness of 3¼ feet, while the thickest of all measures 6 feet. They are divisible into an upper and a lower group, each including two or three workable seams of bituminous coal. Successful bore-holes for coal are proceeding in the Poshan-Chichwan basin.

Magnetites and hæmatites have been proved in several localities, but the most important deposit is that which crops out at the contact between limestone and quartz-augite-diorite at Chi-ling-chen, north of the Poshan valley, on the flanks of the Tieshan. It is from 50 to 65 feet thick, can be followed over a distance of 1¼ miles, and consists of magnetite and red hæmatite with 65 per cent. of iron. Exploration-work is now being conducted on it. In the Ichufu mountains gravels are being washed for diamonds, and the mica-deposits of Chaucheng will repay further attention. Unfavourable reports have been received, however, regarding the plumbiferous deposits of Beishiling. Boring for coal at Tsinkiachung has been temporarily suspended, because the apparatus had reached the limit of its capacity. In the Maushan hills, gold-quartz reefs in granite are being worked with sufficient success. The main reef averages 15½ feet in thickness, is traceable for more than 3 miles, and yields 185 grains of gold per ton.

The now completed Shantung railway links up the Weihsien, Putsum, and Poshan coal-fields, as also the Chilingchen iron-ore-deposits, with the city of Tsingtau, and industrial developments are proceeding apace.

L. L. B.

URANIUM-ORES FROM GERMAN EAST AFRICA.

Ueber Uranerze aus Deutsch Ostafrika. *By* W. Marckwald. *Centralblatt für Mineralogie, Geologie und Paläontologie*, 1906, *pages* 761-763.

Certain mica-quarries worked in the western flanks of the Lukvengule, Uruguru mountains, district of Morogoro, have yielded a variety of altered pitchblende, which, on the mica being split up, is found to permeate it in the form of crystals, some of which attain such a size as to be too heavy for one man alone to carry. By a peculiar and intense process of weathering, accompanied with the formation of pseudomorphs, the pitchblende has been altered into a hitherto unknown mineral—uranyl carbonate. Where the weathering has not proceeded far enough to effect complete alteration, the original black mineral is revealed on removal of the yellow crust of carbonate, and proves to be of remarkable purity, containing very nearly 88 per cent. of an oxide of uranium ($U_3 O_8$). Apart from 7½ per cent. of lead monoxide, the impurities are of little consequence, and the pitchblende possesses a radio-activity exceeding that of the Joachimsthal mineral by 20 per cent. The specific gravity is 8·84. The weathered mineral is nearly pure uranyl carbonate, there being only about 4 per cent. of other constituents in it; its specific gravity is 4·82, and its radio-activity is about the same as that of the pitchblende just described. It is interesting to note, by the way, that the artificial preparation of uranyl carbonate has so far defied the endeavours of the chemists. The name "rutherfordite" is proposed for the new mineral, in honour of Prof. E. Rutherford.

It is not yet certain whether this occurrence of uranium-ores in German East Africa is likely to prove of industrial importance; but, considering the great value that is attached to such ores at the present time, the discovery is worthy of note.

L. L. B.

AURIFEROUS DEPOSITS OF MADAGASCAR.

L'Or à Madagascar. *By* L. Gascuel. *Annales des Mines*, 1906 *series* 10, *vol. x.*, *pages* 85-108 *and* 1 *plate.*

Among the hopes which prompted the French annexation of Madagascar, was the fond illusion that the island would rank high among the gold-producing regions of the world. True it is that the output of precious metal from Madagascar is at present far from insignificant, but it does not remotely approach the expectations that were formed of it ten years or so ago.

For many generations, prospecting for gold was forbidden under penalty of death by the Hova rulers, but this law was repealed in 1883 by the ex-Queen Ranavalona, and mining operations were conducted as a Government monopoly by means of what was, to all intents and purposes, slave-labour. The system proved so unsuccessful that the Malagasy Prime Minister consented in 1886 to grant mining concessions to Europeans, the Government undertaking to furnish labour or to facilitate the recruiting of labour, in consideration of a fixed percentage of the profits of mining. The results were, however, unsatisfactory, and at the time of the French invasion, knowledge of the auriferous deposits of the island had made no advance, the legendary accounts of the natives remaining the chief substitute for such knowledge. After the capture of Antananarivo, prospecting began with a sort of feverish intensity, but the reports of the engineers who traversed the island in every direction on the behalf of European financial syndicates, were without exception unfavourable. They claimed to have found no lodes, only poor placers of limited extent, inadequate to the support of any enterprise conducted on a fairly large scale.

Nevertheless, the gold-output of the island gradually crept up, and new mining districts were opened out—research which had hitherto been confined to the central and western areas having been in 1899 extended to the eastern forest-belt, the mineral wealth of which brought it rapidly to the fore. In 1897, Madagascar had produced only 2,315 ounces of gold; but in 1904, the annual output rose to 79,089 ounces. In April, 1905, the announcement in the newspapers of the discovery of a real lode, very rich and of considerable extent at Ampasimbe, near Beforona, was the prelude of a "boom" which ended disastrously. The pessimism thus engendered is not, however, entirely justified.

All the gold at present got in Madagascar is derived from recent alluvial deposits, which occupy the bottom and sometimes the flanks of the valleys up to a certain height. A few fragments of older terraces are occasionally found clinging to the hillsides, but they are never of any great extent. Three principal gold-producing districts are recognized, being, in their order of importance:—(1) The eastern forest-belt, extending along the coast from Diego Suarez to Fort Dauphin, the really productive portion of which at present lies between Fénérivo on the north and Mananjary on the south; (2) the country around Miandrivago and Ankavandra on the west, with a southern prolongation towards Midargy and a northern towards Mevatanana; and (3) in the centre, the country lying along each side of a line drawn from Antananarivo to Fianarantsoa. The extreme northern and southern districts of the island, especially the southern, are still all but unknown geologically, and they are very sparsely peopled.

The alluvia consist of rolled pebbles, clays, and sands, differing in colour according to the rocks from which they are derived. The pebbles are mostly quartz, and it is seldom that they exceed a man's fist in size.

Sometimes the auriferous stratum is found at the surface, while in other places it lies buried beneath many feet of barren ground. The placers are so loosely compacted that they need only be worked with a spade, and the occasion for the use of the miner's pick arises but seldom. The gold occurs in the native state, in the form of spangles, flakes, more or less rounded granules, and even in comparatively large nuggets; the part played by finely-divided gold-dust in the output is insignificant. On the other hand, big nuggets are rare: the biggest yet found (so far as the author knows) does not exceed 16 ounces in weight. In the *batea*, there remains at the bottom, with the gold, a black sand consisting of magnetite, tourmaline, and impure rutile, with probably some chrome-iron-ore. This black sand is frequently accompanied by fragments of pyrites and more or less rounded bits of tourmaline and zircon of many colours, of garnet, ruby, sapphire, blue beryl, topaz, etc. Recently some prospectors have found it worth while to sort out these hitherto neglected residues, on the chance of picking up some saleable gems. In some places, granules of metallic tin are found with the gold; but whether they represent the results of an accidental smelting of cassiterite-outcrops during the seasonal grass-fires, or the melting-down during those same fires of the preserve-tins accumulated in camp-rubbish, is still an open question. Considering the abundance of pegmatitic rocks in the island, and considering that cassiterite and granules of tin are known associates of gold in other countries in alluvia very similar to those of Madagascar, the occurrence of stanniferous deposits is, at all events, not improbable.

After explaining how the gold-bearing alluvia at the bottom of certain valleys could be worked over again at a profit after an interval of a few years' rest, the author describes the method of working, which is of the simplest and most primitive description. Natives (men and women) recruited by the European concessionaire from the villages of the Imerina and Betsileo countries, build themselves a sort of mining camp in the neighbourhood of the white man's dwelling, dig the stuff out of the alluvia, and wash it for gold, on the understanding that they sell to him all the metal that they get at a price which is equivalent to about a shilling or 13d. for 10 grains. Mining work begins in the majority of cases in April, after the rains and the rice harvest are over, and in October, towards the close of the dry season, most of the natives leave the mining camps to go back to their paddy-fields. Ground-sluicing is well understood and practised, and the Malagasy (thanks to the experience gained in cultivating a plant needing so much irrigation as rice) show a quite remarkable aptitude in constructing canals for bringing water to the gold-washeries when needed. Nevertheless, the method of working is sufficiently wasteful; for instance, good auriferous strata remain hidden away under carelessly heaped-up piles of barren ground or "cover" dug out of another portion of the placer. Moreover, some of the poorer gold-bearing strata are left untouched, because the natives could not earn therefrom, on the present system, a sufficient living wage. At some future time, such deposits may well repay working on a large scale. In fact, the author holds that, so far, the auriferous deposits of Madagascar have been merely skimmed, not thoroughly worked; and it is on thorough and economically-devised working that the future prosperity of the gold-mining industry in the island will depend. The abundance of water-power everywhere available is an important factor in this respect.

Quartz is of most extraordinarily frequent occurrence in Madagascar—hills are covered with it: it builds up whole ranges of mountains, and some of it is quite conceivably auriferous. In fact, extensive outcrops of solid rock

containing gold, but of extremely unequal tenour, are known to occur, especially in the Central districts. They will prove undoubtedly workable, with the help of cheap labour and cheap motive power. What is now needed is careful study of the local conditions of each of these outcrops. Lodes apparently they are not, but rather huge lenticles of quartz intercalated among the schists which rest upon the basement-granites. This is traversed by numerous dykes of pegmatite, which have, moreover, metamorphosed grits, limestones, and shales into quartzites, marbles, mica-schists, and gneisses, etc. At a later date, all the rocks were more or less infiltrated by silicifying solutions carrying gold and sulphur. There are some thin and discontinuous, locally rich lodes, where the granite itself has been laid bare; but these are not likely to prove industrially important. Still, there are some few localities where it may be found possible to work even these lodes at a profit. The extreme variability of the auriferous quartz of Madagascar in aspect, colour, texture, etc., is very puzzling for the prospector; but the author is confident that a patient resolve to overcome this and other difficulties will, in the long run, be amply repaid. L. L. B.

RARE MINERALS FROM MANICALAND, SOUTH AFRICA.

Sur quelques Minéraux Rares des Mines Aurifères du Manicaland. By J. Couyat. *Bulletin du Muséum d'Histoire Naturelle*, 1906, *No.* 1, *pages* 74-76.

The district of Mozambique, recently explored by an emissary of the French Government, occupies a parallelogram extending some 22 miles from east to west and some 14 miles from north to south, near the borders of Rhodesia. The Revué and its numerous tributaries which water this district come down from a granitic massif the altitude of which varies between 2,000 and 6,000 feet above sea-level, and the centre of the basin appears to consist chiefly of metamorphic quartzites and mica-schists, seamed by a multitude of veins of auriferous quartz. These quartz-veins, and also the gold-bearing alluvia, are worked at no less than two hundred and fifty different localities, whence it may be inferred that gold is extremely abundant within this comparatively restricted area. The assays vary from 1½ pennyweights to 30 ounces per ton of crude material. The kaolin got from the Zambuzi, Revué, and other rivers, contains as much as 2 pennyweights per ton, but the richest localities are where the quartz-veins contain from 6 to 7 ounces per ton. This auriferous quartz differs in aspect: that of the northernmost belt, upstream from the Shimezi confluence, is mostly hyaline; the quartz of the central and richest belt, between the Shimezi and the Revué, is bluish-grey; and that of the southernmost, between the Zambuzi and the Menenir, is either amethystine, or white encrusted with hæmatite.

The customary associates of the gold in this area are galena, argyrite, stibine, and cerussite; and the various compounds of iron, such as pyrites, marcasite, mispickel, magnetite, hæmatite, and siderite, abound—some being intercrystallized with the quartz, others impregnating the sedimentary deposits. On the Edmundian reef, a chalcopyrite containing 32 per cent. of metallic copper is actively worked.

Among the samples of quartz examined by the author, many were covered with tiny crystals, the outcome of the decomposition of sulphidic compounds of lead and of the formation of chlorarseniates, chlorovanadates, and molybdates (mimetite, vanadinite, and wulfenite). The hexagonal green crystals of mimetite, well-developed little prisms of uniform height, recall the mimetite

of Cornwall and Johanngeorgenstadt. The brown or orange-coloured prisms of vanadinite are of unequal length, and generally resemble the Arizona mineral; and so do the rare, tabular, orange-coloured crystals of wulfenite recall the wulfenite of Arizona.

The Zambuzi schists are traversed by veins, occasionally exceeding 4 inches in breadth, of a fine greenish talc, in large laminæ, like that of the Tyrol. Actinolite and asbestos also occur; and the samples of tourmaline are probably derived from the granulitic veins of Andrada, or from those which cut across the bed of the Zambuzi.

The alluvia are all more or less gold-bearing, and have been the object of mining operations since remote ages—as witness the innumerable shallow pits ranged along the valleys over a breadth of more than half a mile, and so close one to the other that there must have been only just room for a miner to pass in between. L. L. B.

NATIVE COPPER IN BRAZILIAN DIABASES.

Ueber das Vorkommen von gediegen Kupfer in den Diabasen von São Paulo. By E. Hussak. *Centralblatt für Mineralogie, Geologie und Paläontologie*, 1906, *pages* 333-335, *with* 1 *figure in the text.*

Diabasic rocks are of widespread distribution in the northern and north-western portions of the State of São Paulo, in the form chiefly of sills, but not infrequently in that of dykes and bosses, intruded among the sandstones, shales, etc., of the Permian system. The lateritic weathering of the sills furnishes the red earth beloved of the coffee-planter. The building of several new lines of railway has opened up several fresh exposures of diabase; and, in one case especially, near Botucatù, district of Sorocabana, the chalcedony which fills the amygdaloidal cavities in the rock is encrusted with a black hydrated silicate of iron. Between this black crust and the chalcedony are found thin, irregular, highly lustrous flakes of native copper, unaccompanied by sulphides or carbonates of the metal. It is noteworthy that the flakes of copper are invariably surrounded on all sides by the above-mentioned black crust. Although a chemical analysis of the diabase itself fails to reveal any trace of copper, the author is of opinion that the metallic flakes are derived from the decomposition of copper-pyrites previously dispersed throughout the rock in a state of fine division. It is not found now in the hand-specimens, but its leaching-out has given rise to limonite, hydrated silicate of iron, and native copper. The occurrence of minute pyritic granules, irregularly distributed within the basic eruptive rocks of Brazil, has long been recorded.

A similar occurrence of native copper in the coarser-grained, non-amygdaloidal diabase of the Fazenda Serodio, near São Simão, is also described. Here the flakes of native copper are bestrewn amid a black crust, identical with that already mentioned, on the walls of narrow clefts and fissures. Chalcedony and zeolites are conspicuous by their absence. The origin of the native copper is thought to be the same as that assigned to the previous instance.

In the southern states of Brazil, as, for example, near Guarapuava in Paranà, native copper occurs in quartz-chalcedony geodes, in association with a green earthy crust of silicate of iron. But there it is somewhat more abundant, sufficiently so indeed to warrant an attempt at mining it, and a concession for that purpose has already been granted. L. L. B.

DIAMANTIFEROUS DEPOSITS IN BRAZIL.

Über die Diamantlager im Westen des Staates Minas Geraes und der angrenzenden Staaten São Paulo und Goyaz, Brasilien. *By* Dr. E. Hussak. *Zeitschrift für praktische Geologie*, 1906, *vol. xiv., pages* 318-333, *with* 5 *figures in the text.*

The deposits described by the author appear to him to have an especial interest for two reasons: (1) although they are sedimentary deposits, they differ in constitution and in the mineral associates of the diamond from the placers of Diamantinas and Bahia; and (2) they show a certain amount of resemblance with the Kimberley formations. The district with which he deals lies somewhat away from Diamantinas, in the extreme west of the State of Minas Geraes, in the so-called "Mining Triangle," which includes a portion of the States of São Paulo and Goyaz. But diamonds have been found farther afield, southward as far as Franca and northward as far as Catalão. A big diamond weighing 600 carats, as some aver, was discovered recently in the Rio Verissimo (Goyaz), but was smashed up owing to the sheer ignorance of the workpeople. Generally speaking, the rocks of the district are made up of steeply-inclined crystalline schists, with which are associated metamorphosed basic eruptives (diabases and gabbros), unconformably overlain by tough unfossiliferous red sandstones, said to be of Triassic age (the Botucatù grits). Among these are intercalated sills and dykes of an aphonitic diabase poor in olivine. In the southern part of the State of Goyaz, the Triassic sandstones are, however, wanting, and the barelaid crystalline schists form *mesas* some 3,000 feet high. But, of whatever rocks the smooth-worn *mesas*, a characteristic feature of the landscape of the region, may consist, they are generally mantled by *canga* or *gorgulho* (gravels and sands), intermingled with fragments of quartz and more recently-formed limonite and pyrolusite, rounded nodules of diabase, etc., some 6 to 10 feet thick. The author holds that this *canga* is not so much an alluvial deposit, as the outcome of the weathering of the solid rocks by the agencies of a dry tropical climate. He draws attention to the analogies which undoubtedly exist between the diamantiferous regions of Brazil and those of South Africa.

The first district to be described is that of Franca, and here the characteristic feature is the extreme divergence of the mineral-associates of the diamond from those observed in Diamantinas: they include, besides quartz, predominantly tourmalines, gorceixite (phosphatic), *favas* (beans), pebbles of titanium-ore, and a few gems, such as sapphire, chrysoberyl, zircon, etc. Then the tuff-like rocks of Uberabá, rich in perowskite, are described, and it is shown that they originate from a deep-seated rock resembling iolite-jacupirangite, in other words, an eruptive pyroxenite. Thèse tuff-like Uberabá rocks are certainly comparable with kimberlite, although they are much poorer in olivine, and richer in garnet, pyroxene and titaniferous magnetite; in structure the contrast between the two varieties of rock is very marked. North of Uberabá, towards the frontier of the State of Goyaz, are a series of rivers which have long been known to carry diamonds, and the gravels and sands have recently been washed with success; the *favas*, or beans of titanium oxide, being regarded as good indicators of the presence of the gems. A description is given of the old Agua Suja mine; and the author, remarking by the way that operations have recently been resumed in that concession, points out the desirability of putting down borings (if only to a depth of 150 or 160 feet) on the *mesa*, in order to ascertain whether the sedimentary deposits (which carry the diamonds) are everywhere of the same composition and the same thickness.

It is again observed how different are the mineral-associates of the diamond, in this district also, from those which are characteristic of the Diamantinas deposits. Rich finds have been recently recorded from the fluviatile sands of the Rio Verissimo, as above stated; here, and along the Rio Douradinhos, the number of big stones, generally fragmentary and not of the purest water, contrasts with the usually small stones of Agua Suja, etc.

The author describes the titaniferous magnetite-deposit, which he discovered in 1893, some 12 miles east of Catalão, and then refers briefly to the diamantiferous sands of the Rio Claro.

Discussing at some length the genetic relationship between the sedimentary and tuff-like deposits and the eruptive rocks of the diamantiferous region of the "mining triangle," he arrives finally at the conclusion that the question as to what was the original matrix of the Brazilian diamond still remains unanswered. L. L. B.

PALLADIUM AND PLATINUM IN BRAZIL.

Über das Vorkommen von Palladium und Platin in Brasilien. *By* Dr. Eugen Hussak. *Zeitschrift für praktische Geologie*, 1906, *vol. xiv., pages* 284-293, *with* 5 *figures in the text.*

The author states at the outset that this paper is to be regarded as supplementary to that published by him in 1904,* the more so that in 1905, owing to friendly assistance from various quarters, he was able to carry still further his investigations into the occurrence of palladium and platinum in Brazil.

In assaying the platinum-ores, he found that it was impracticable, in view of the comparatively small quantity of material available for the purpose, to determine the proportion present of the rare elements, osmium, rhodium, and ruthenium; but, on the other hand, tests were always made for gold, silver, copper, and lead.

The platinum-sands from Nizhni Turinsk and other Russian localities, in which that metal is proved to have been derived from peridotites rich in chromite, show remarkable resemblances with the sands from the Rio Abaete and its tributaries in the State of Minas Geraes, Brazil; and the author claims, as an observation new to science in respect of the platinum from these widely separated regions, that it exhibits microscopic intergrowth with osmiridium. An analysis of the Rio-Abaete mineral shows it to contain 82·81 per cent. of metallic platinum, 9·62 of iron, with traces of palladium and copper, and 7·57 per cent. of insoluble residue (? mostly osmiridium). In the sands of that river, diamonds and a small amount of gold occur for a long distance upstream; but the sands of certain tributaries are said to be far richer in platinum than those of the Abaete itself, which would hardly repay the cost of dredging and concentration. Certain pebbles called *favas* (or beans) of a compact, brown, jasper-like mineral are very common constituents of these alluvia (as also in association with the diamonds at Diamantina and Borgagem), and this mineral turns out to be a new species (named and described in 1906 as gorceixite), a hydrophosphate of aluminium and barium. Some of the *favas* which incline in colour towards dark red, also contain strontium. Detailed descriptions are given of a chromite-bearing olivine-rock, a picrite-porphyry, and an amygdaloidal olivineless basalt, which all occur in the Abaete region. The first-named recalls irresistibly the primary matrix of

* Vol. cxiii. of the *Sitzungsberichte*, of the Imperial Academy of Sciences in Vienna.

the platinum of Nizhni Tagilsk in the Urals; the second is extraordinarily rich in perowskite, one of the constituents of the insoluble residue from the Abaete platinum; and the groundmass of the third is built up of augite, magnetite, and perowskite. A magmatic relationship between these three rocks is inferred.

In form, chemical composition, and mode of occurrence, the platinum mineral found on the eastern flank of the Serra do Espinhaço, between Conceição and Serro, differs entirely from the Abaete platinum. It appears to be in its primary deposit, to have no genetic connexion whatever with olivine-rocks, but to be derived from the Palæozoic (?) conglomeratic sandstones (or from the quartz-veins by which they are seamed) unconformably overlying the crystalline schists (or phyllites and quartzites of the Itabirite Series). Similarly, the platinum of Condado near Serro, exempt as it is from all signs of erosion through transport, appears to have been formed *in situ*, probably by decomposition of pyritic minerals occurring in the above-mentioned sandstone or its quartz-veins. This Condado platinum occurs in the sands of a stream which takes its source among the conglomeratic sandstones, and is associated with diamonds, rutile, anatase, xenotime, etc. Downstream, where the products of erosion of the crystalline schists come in, high-grade gold and palladium-gold make their appearance in conjunction with the platinum. Analysis yields the following results, which are in marked contrast with the assays of the Abaete platinum:—Metallic platinum, 73 to 74 per cent.; palladium, 21·82 to 21·77; iridium, 0·88 to 0·08; iron, 0·10 to trace; insoluble residue, 0·42 to 0·92 per cent. While the one may be termed a palladium-platinum, the other is distinctly an iron-platinum (see the first analysis above). The Condado occurrence is one of the oldest known in Brazil.

Finally, the author describes the platinum of the Corrego das Loges, near Conceição, a tributary of the Rio Santo Antonio. Angular bits of quartz are intergrown with the metal, and their presence is one of the circumstances which lead to the conclusion that this platinum, like the Condado mineral, is a precipitate from solutions, is (in short) of secondary origin. The primary matrix was the micaceous quartzite of the district, or the tourmaline-bearing quartz-veins which traverse that rock. On analysis, the platinum yields rather more than 83 per cent. of the pure metal, with sometimes as much as 3·6 of iridium and 3·64 of palladium. On the whole, none of the platiniferous deposits of Brazil are likely to repay working. The concluding section of the paper is devoted to the description of the occurrence of palladium-gold, especially at Candonga. L. L. B.

TOURMALINE-BEARING COBALT-DEPOSITS IN CHILE.

Turmalinführende Kobalterzgänge. *By* O. Stutzer. *Zeitschrift für praktische Geologie*, 1906, *vol. xiv., pages* 294-298, *with* 4 *figures in the text.*

The first really detailed notice of the occurrence of tourmaline in metalliferous lodes is said by the author to date from Dr. von Groddeck's paper of 1887 on the tourmaline-bearing cupriferous ores of Tamaya, wherein these were asserted to be unique of their kind. In 1897, Dr. Stelzner, dealing with similar occurrences in other cupriferous ores of Chile, arrived independently at the same conclusions as the first-mentioned writer, and now specimens of tourmaline-bearing cobalt-ores are forthcoming from the Blanca mine at San Juan, department of Freïrina, in the province of Atacama. It may be mentioned, by the way, that specimens of cobalt-ore from the Vallenar mines (in the neighbouring district) were found to be destitute of tourmaline. The San Juan ores occur in quartz-lodes traversing mica-schists; and the

sole primary ore present is cobalt-glance, distinguishable from cobaltiferous arsenical pyrites by the extraordinarily small proportion of iron which it contains, and also by its crystalline habit (small cubical, octahedral, and pentagonal-dodecahedral crystals). It is distinguishable again from smaltine by its fissility, and its unmistakably sulphurous odour and tendency to film over with sulphur when tested by the blowpipe. The secondary ores include cobalt-bloom (erythrite), and cobaltiferous manganese-ore.

The tourmaline occurs:—(1) In the form of a black, extremely porous mass, speckled with brick-red spots of cuprite. Under the microscope, the sole transparent mineral-constituent is seen to consist of small green prisms of tourmaline. This black stuff is got from the superficial portion of the outcrop, and must have originally been the actual gossan of the lode, the tourmaline now alone surviving, thanks to its exceptional ability to resist the various agents of weathering. (2) In the form of a fine-grained black mass, impregnated with dull, bluish-black, cobaltiferous manganese-ore. This material is also extremely porous, all other constituents but the tourmaline, the above-mentioned ore, and a mere trace of quartz, having been leached out of it. The absence of cobalt-glance, the deeper-lying primary ore, is a sufficient indication that this specimen also comes from the upper portion of the lode, the cobaltiferous manganese-ore representing a decomposition-product of the cobalt-glance. (3) In the form of radiating crystals within a rich black merchantable ore, from a somewhat lower level, which is visibly intermixed with quartz and erythrite. Here again, the porous structure of the ore and the absence of cobalt-glance indicate that we are still dealing with portions of the lode that are accessible to weathering agencies. (4) Included within lustrous cobalt-glance, and also crystallized around it. This last specimen forms a tough compact rock, consisting, besides the two minerals already mentioned, of white quartz and erythrite. The microscopic evidence shows that the tourmaline must have originated contemporaneously with the cobalt-glance, although in part it crystallized later than that ore.

The presence of traces of cuprite and malachite in the cobaltiferous specimens suggests a passage into the tourmaline-bearing cupriferous ores now known to be fairly common in Chile. The paper concludes with a *conspectus* of all the metalliferous deposits hitherto recorded as containing tourmaline, including stanniferous deposits, cupriferous deposits, pyritic, arsenical and cupriferous gold-quartz, and ferruginous deposits. L. L. B.

COAL- AND LIGNITE-FIELDS OF THE ROCKY MOUNTAINS.

Les Bassins lignitifères et houillers des Montagnes Rocheuses. *By* Étienne A. Ritter. *Annales des Mines*, *series* 10, 1906, *vol.* x., *pages* 5-84, *and* 4 *plates.*

The coals of the Rocky Mountains, exhibiting all the gradations from lignite to anthracite, are mostly assignable, as regards age, to the Laramie or Cretaceo-Tertiary group. The basins in which they occur form a discontinuous belt, which can be followed right up the North American continent, from the North of Mexico, through the Western States and British Columbia, into the frozen regions of Alaska. On the Pacific coast there are, moreover, some coal-basins of small extent, of Eocene and Oligocene age. Largely worked as they are already, the coal-basins of the Rockies hardly produce a quarter of their possible output, and industrial activity in those regions is progressing at such a pace that the demand for coal outruns the present supply. The want of available labour is much felt in this respect.

The author appends maps which give a general view of the situation of these coal-basins: they cover an area of 42,500 square miles, while to the east, in the States of North Dakota and South Dakota, is a double lignite-basin extending over 54,000 square miles. He plots out on his map some forty separate basins: but, what are now worked as two separate basins, were often originally deposits laid down in a single lagoon, and later orogenic movements have plicated the deposits and thrust up between them a lofty mountain-range. In sketching the tectonic history of the coal-fields, the author points out that the Rocky Mountains, far from constituting a series of parallel anticlines and synclines, are built up of a suite of monoclinal folds or of anticlinal domes emerging from a horizontal plain. Consequently, the coal-fields, instead of lying in the midst of a synclinal basin, usually form part of a monoclinal limb, or else rim round some anticlinal dome. The Laramie stage corresponds to a geographical change marked by the recession of the sea; along the embryo range of the Rockies, semi-marine and semi-lacustrine deposits were laid down in bays and lakes. In lagoons not entirely open to the sea, vegetation decomposed practically *in situ*, and there is no question here of coal-seams formed by driftwood. Perhaps the more recent date of deposition of the coal will serve to explain how it has failed to undergo quite the same amount of metamorphism as the Carboniferous or true Coal-measure coals of Pennsylvania, Great Britain, France, or Belgium.

As to the anthracite of the Rocky Mountain region, the author connects it with the presence of eruptive rocks, and the rapid local action of volcanoes, of obviously later date than the deposition of the coal. But the metamorphism thus induced is narrowly localized, and one and the same seam within a single basin may show all the gradations from a semi-lignitic coal, through bituminous coal and anthracite, to the natural coke in immediate contact with the eruptive rock. In some few cases, there is a passage without any intermediary from lignitic coal into coke. The distance between an intrusive dyke or a laccolite and the anthracite ranges from $6\frac{1}{2}$ to 65 feet at most; beyond this distance, often for many thousand feet, comes a bituminous coking coal; beyond that again is a coal poorer in carbon, but in every way suitable for firing boilers and furnaces. Immense lava-flows overlie much of the Trinidad-Raton coal-basin, for instance, without having affected the deep-lying coal-seams: in order to metamorphose these, the eruptive magma must either burst through them, or thrust itself into the neighbouring strata; whence it may be inferred that vulcanicity has acted rather through such instruments as superheated steam and the gases accompanying eruption, than through the direct agency of heat.

A vast number of analyses are tabulated, very many being derived from American and Canadian publications. A high percentage of water is characteristic of those Rocky Mountain coals that have best retained their original lignitic nature. These lignites are very susceptible to atmospheric agencies, crumbling away if they are carried for any considerable distance on the railroad, or if they are stacked for many months in a storage-depôt. In considering the quality of various coals, especially when comparing them with the true Coal-measure coals of Europe, the analyst is apt to forget the importance of specific gravity, and the author laments the almost entire absence of such data in regard to these American coals. He notes that those basins that yield the best results for coke in the analyses, and in fact produce the best quality of coal, have usually thinner seams than the basins where the lignitic taint yet sticks to the mineral. It seems fairly evident that, in losing some of their water and their gaseous constituents, the seams have proportionately

diminished in thickness. In comparison with the true Coal-measure seams of Pennsylvania and France, the Rocky Mountain seams exhibit more rapid variations in thickness, number, physical and chemical properties, and other characters.

The second chapter entitled "Geographical Description of the various Lignite and Coal-basins," deals in succession with those of British Columbia, Montana, Wyoming, Colorado, Utah, Idaho, New Mexico, and Coahuila. Turning then to the Pacific coast, the author describes briefly the coal- and lignite-fields of the Alaskan seaboard, Vancouver and Queen Charlotte Islands, the States of Washington, Oregon, and California.

The third chapter deals with the methods of working the mines, and the fourth is taken up with statistics of output, etc., wherein comparisons are drawn with the corresponding statistics from the various coal-fields of France. The output from the Rocky Mountain coal-basins within the last fifteen years has increased by 282 per cent., as compared with an increase of something over 50 per cent. in France. Although the annual working-days of the French miner exceed in number by 1 to 10 per cent. those of the Rocky Mountain miner, the latter sends to the surface daily 30 to 35 per cent. more coal than his European fellow-pitman. It should be borne in mind, however, that in most cases, once the seam has been worked out, the roof is allowed to cave in by the Rocky Mountain miner, as the concessionaires are owners of the surface as well as the subsoil, and the land is generally of small value. In France, labour and time must needs be spent in taking precautions to avoid caving-in of the roof. The author considers that coal-cutting machines have been introduced into the Rocky Mountain mines somewhat haphazard; instead of conducting a thorough preliminary investigation as to the suitability or otherwise of the machines, those responsible have simply left it to practice to determine whether coal-cutting machines were urgently needed or not. Only in Wyoming have these machines been uniformly successful, and there the seams are thick and lie all but horizontal.

It so happens that the coal-fields that form the subject of this memoir include a vast area of the United States, which is destined to absorb within the next twenty years the westward-setting tide of immigration, an area where all the newest railway-lines of the Union are under construction or survey, and where great irrigation-reservoirs are heralding the triumphant march of agriculture into a land that was formerly desert. A brilliant future seems, therefore, assured for the coal-mining industry of the Rocky Mountains.

L. L. B.

PRECIOUS CHRYSOLITE OF ST. JOHN'S ISLAND, RED SEA.

Sur le Gisement de Chrysolite de l'Île Saint-Jean (Mer Rouge). By L. Michel. *Bulletin de la Société française de Minéralogie*, 1906, *vol. xxix., pages* 360-361.

A few years ago, a deposit of precious chrysolite was discovered on this island, yielding large crystals of the gem, of a colour, brilliancy, and transparency comparable with the similar characteristics of the Brazilian chrysolite. The deposit is, therefore, of industrial value. The chrysolite-crystals are disseminated in a gangue which essentially consists of serpentine, magnetite and gymnite (deweylite). This gangue is seamed by fissures which are encrusted with rather peculiar fusiform crystals. Under the microscope these prove to be made up of a "skeleton" of quartz clothed with a beautiful green mammillated mineral, the chemical composition of which exactly corresponds with that of the hydrocarbonate of nickel, texasite ($H_{12}Ni_3CO_{11}$). Now, texasite has, so far, been found in very few localities indeed; and both it and

the above-mentioned gangue represent, at all events in part, the alteration-products of a nickeliferous peridotite. L. L. B.

IDENTIFICATION OF COPIAPITE WITH JÁNOSITE.

Nochmals Copiapit und Jánosit. *By* E. Weinschenk. *Földtani Közlöny*, 1906, *vol. xxxvi., pages* 359-366.

In this somewhat controversial paper, the author first of all points out that the name "copiapite" cannot be used to define a whole group of natural sulphates of iron, but is applicable, like all other mineral specific names, to one of them alone, which has distinct chemical and physical characteristics.

He then describes in detail the optical and crystallographic identity between the so-called jánosite and copiapite; in a previous memoir he had already shown that they had the same index of refraction and the same pleochroism. The jánosite appears to have been obtained only in fine scales, and therefore differences of specific gravity do not count for much; nor, considering that the material analysed by the discoverer was admittedly impure, do differences in chemical composition carry great weight. However, the author isolated some perfectly pure jánosite from the material sent to him by Dr. H. Böckh, and found that, in specific gravity and in percentage of iron, it coincided exactly with copiapite, in contradistinction to the results obtained by Dr. Böckh. The true formula of copiapite is $2\,Fe_2O_3\,5\,SO_3 + 18\,H_2O$; and, in contrast with the closely-allied minerals, coquimbite and quenstedtite, which are only found in rainless desertic regions, copiapite is perhaps one of the most widespread products of the oxidation of sulphidic iron-ores.

The conclusion is that jánosite must be eliminated from the catalogue of mineral-species. L. L. B.

SULPHATE-OF-IRON MINERALS: COQUIMBITE, COPIAPITE, AND RÖMERITE.

Beiträge zur Kenntniss der chemischen Constitution und der Genese der natürlichen Eisensulfate. VI. *By* R. Scharizer. *Zeitschrift für Krystallographie und Mineralogie*, 1907, *vol. xliii., pages* 113-129, *with* 2 *figures in the text.*

The author first of all describes his repeated and finally successful endeavours to reproduce artificially the ferrous-sulphate mineral coquimbite, which led him to the conclusion that this mineral can only be generated from a solution containing an excess of sulphuric acid, over and above the amount of such acid necessary for the formation of normal ferrous sulphate. Or, in other words, coquimbite, associated with acid ferrous sulphate, only arises from solutions wherein the quotient of the molecular ratio, $SO_3 : Fe_2O_3$, is greater than 3 and less than 4.

Experiments with aqueous solutions of römerite proved that, from a solution containing ferric oxide and sulphuric acid in the molecular proportion, 1:3, it is not normal ferrous suphate that will crystallize out, but a mixture consisting of the mineral copiapite and acid ferrous sulphate, a result expressed by the chemical equation: $3\,Fe_2S_3O_{12} = Fe_2S_4O_{15} + Fe_4S_5O_{21}$.

Römerite can only be formed when acid ferrous sulphate and ferric sulphate re-act one upon the other in the presence of minute quantities of water. On mere exposure to a damp atmosphere, römerite splits up into its components; whereupon ferric sulphate (on account of its lesser solubility) partly separates out as a solid; a small portion thereof, together with the ferrous sulphate, going into solution. L. L. B.

FRIGIDITE, A VARIETY OF TETRAHEDRITE.

Tetraedrite del Frigido (varietà Frigidite) e Minerali che l'accompagnano. By ERNESTO MANASSE. *Atti della Società toscana di Scienze Naturali*, 1906, *Memorie, vol. xxii., pages* 81-93, *with* 3 *figures in the text.*

The old Frigido mine, at one time worked for its copper-ores, especially chalcopyrite, but now abandoned for several years, is about $\frac{3}{4}$ mile distant from the town of Massa, in Tuscany, by the road that runs to Il Forno and La Tambura. The adits, lying very close together, are opened up in both flanks of the small valley through which courses the Frigido torrent, in rocks identical with those among which, at Seravezza, only a little distance off, occurs the Bottino silver-lead lode. They are tourmaline-bearing mica-schists of Permian age, of extremely variable texture and coloration. Among the metalliferous ores found in the ferruginous quartz-veins that traverse these rocks are chalcopyrite (extremely abundant), pyrrhotine, tetrahedrite, pyrite, marcasite, galena, blende, etc., specimens of which are represented in the Tuscan mineralogical collection in the Pisa Museum. The author examined this collection, besides obtaining specimens *in situ* on the occasion of a recent visit to the abandoned mine.

The nickeliferous variety of tetrahedrite, to which the name of "frigidite" was originally applied by the late Prof. A. d'Achiardi, occurs in generally compact masses of a dark steel-grey colour. Its hardness corresponds to 4 in the recognized scale, and its specific gravity varies between 4·7 and 4·8. It melts easily before the blowpipe, giving rise to white antimonial fumes. Insoluble in hydrochloric acid, it is attacked by nitric acid, leaving a residue of sulphur and metantimonic acid; while it is completely soluble in *aqua regia*. Such rare crystals of the mineral as occur show the tetrahedral habit. Complete qualitative analyses of portions of three specimens revealed the presence therein of sulphur, antimony, arsenic, lead, copper, tin, iron, zinc, and nickel. Thereafter the author proceeded to make quantitative analyses of material from the same specimens; and, after trying other methods which proved unsatisfactory, he used *aqua regia* at first in the cold, and then warm (but always much below a temperature of 212° Fahr.). The percentages yielded by these analyses ranged as follows:—Lead, from trace to 0·26 per cent.; copper, from 30·04 per cent. to 37·54 per cent; tin, traces only; iron, from 6·01 per cent. to 9·83 per cent.; zinc, from 0·59 per cent. to 1·98 per cent.; nickel, from 0·14 per cent. to 3·46 per cent.; antimony, from 28·82 per cent. to 29·54 per cent.; arsenic, trace to 1·50 per cent.; sulphur, from 24·48 per cent. to 25·70 per cent. From these results, the author deduces for the mineral, either the general formula: $3\,Cu_2S.R'''_2S_3+\frac{1}{2}(6\,R''S.R''_2S_3)$; in which R″ represents Sb + As and R‴ represents iron and nickel in the ratio of 4:2; or the formula: $3\,Cu_2S.Sb_2S_3+\frac{1}{4}(6\,R''S.Sb_2S_3)$; wherein R″ represents iron and zinc in the proportion of 5:1, nickel being left out of account because of its small percentage in the specimens upon which the second formula is based. Despite the great variability, however, in the proportion of nickel from specimen to specimen, frigidite is properly defined as a nickeliferous variety of panabase. Although cobaltiferous varieties of tetrahedrite are fairly common, nickeliferous varieties are exceedingly rare, especially containing such quantities of nickel as occasionally occur in frigidite. Besides this mineral, the author describes the siderite, pyrrhotine, chalcopyrite, quartz, etc., which are associated with it at Frigido. L. L. B.

OCCURRENCE OF KIMBERLITE IN FISSURE-VEINS, ETC.

Über das Vorkommen von Kimberlit in Gängen und Vulkan-Embryonen. By F. W. Voit. *Zeitschrift für praktische Geologie*, 1906, *vol. xiv., pages* 382-384.

The great activity of diamond-prospectors in South Africa of late years has thrown much new light on the occurrence of kimberlite. It has been shown that the blue and yellow ground, far from being of restricted occurrence, is to be found all over South Africa in fissure-veins and pipes, from Central and Northern Cape Colony to Griqualand West, from Damaraland to Rhodesia, and northward from the Zambesi into British East Africa, without speaking of the Bloemhof and Pretoria districts in the Transvaal and the Orange River Colony: in fact, throughout the western ranges of the Drakensbergen, there is hardly a locality where the precious diamantiferous breccia has not been found; and now we hear of similar finds in Kentucky on the one hand, and in New South Wales on the other.

The author thinks that great economic importance may ultimately attach to the practice now adopted by South African diamond-prospectors of following up fissure-veins that show a good outcrop, until they come upon the diamantiferous deposit, basing themselves herein on the generally admitted fact that "the pipes all lie upon fissure-veins."

The kimberlite in the veins differs from that in the pipes structurally, but not mineralogically, its composition being identical in both cases. The vein-rock is a yellowish or bluish, very uniform aggregate of fragments of serpentine and mica of unvarying size, with small and sparse fragments of accessory minerals. In general appearance and texture, it resembles a doleritic diabase. But the pipe-rock, on the other hand, is extremely variable, the groundmass consisting all but exclusively of serpentine while the tiny flakes of mica that do occur are barely visible. Accessory minerals are very abundant, often in the form of big well-developed crystals. The coarsely granular structure of the pipe-rock recalls plutonic rocks which have solidified under pressure.

It may, therefore, be inferred that the vein-kimberlite solidified under conditions different from those under which the pipe-kimberlite solidified. The veins are almost invariably arranged in parallel series, and can thus be followed for mile after mile across country; while the pipes, although in a way grouped together, occur in sporadic batches, and are evidently of later origin than the veins. At great depths their cross-section is almost exactly circular, and makes one think of the effect of an old-fashioned cannon-ball being shot through a partition.

Although both varieties of kimberlite belong geologically to the same horizon—that is, to a time when the deposition of the Karoo sediments had begun, their protrusion took place at two different stages: the vein-kimberlites first welled up through contraction-fissures in the earth's crust, widening these fissures as they did so, and sweeping along with them fragments of the country-rock. Thereupon, the mass of the deep-seated kimberlite-magma having thus suffered a diminution, pressure on the remainder of the magma was so far released as to cause it to resume the fluid state, and to cause the associated water to flash into steam, sufficient dynamic energy being thus produced to permit of an explosive uprush of the magma forming the pipe-kimberlites. But the farther up they travelled, the more they lost in explosive energy; the associated gases escaped through various fissures; and all that the upwelling magma was then capable of, was to thrust up to a certain

extent the overlying rocks and to squeeze itself out laterally after the manner of a laccolite. L. L. B.

NEPOUITE, A NEW NICKELIFEROUS MINERAL.

Note sur une Espèce minérale nouvelle : la Népouite, Silicate hydraté de Nickel et de Magnésie. *By* E. GLASSER. *Bulletin de la Société française de Minéralogie*, 1907, *vol. xxx.*, *pages* 17-28.

All the hydrated silicates of nickel and magnesia which have been thus far described, whether from New Caledonia or elsewhere, occur in amorphous masses, although occasionally (and especially in noumeite) microscopic investigation reveals the presence of a cryptocrystalline structure recalling that of chalcedony. Recently, among several lots of nickel-ore specimens collected by the author in New Caledonia, he discovered certain silicates, in many respects chemically similar to garnierite and noumeite, but undoubtedly crystallized and possessed of very different optical properties from those exhibited by the two last-mentioned minerals. The new mineral occurs in the form of minute, roughly hexagonal flakes, frequently adpressed one against the other so as to constitute vermicular aggregates analogous to those formed by the chlorites. It is found as an extremely fine, ashen-green, crystalline dust among the complex débris that fill up the interstices between the more or less crumbly blocks of nickeliferous serpentine, which latter often constitutes the best ore that is to be got in the island. Detailed analyses are tabulated of five specimens, and the author proposes for the mineral the formula: $2\,Si\,O_2 . 3\,Ni\,Mg\,O . 2\,H_2\,O$. The name assigned to it, nepouite, is derived from Nepoui, the locality whence it was first obtained. The specific gravity is variable (2·47 to 3·24), and appears to depend on the amount of nickel which any given specimen may happen to contain, increasing, of course, in the same ratio as the percentage of that metal; this statement holds good also of the green coloration of the specimen, which is the more vivid the richer it is in nickel. The hardness lies between 2 and $2\frac{1}{2}$. In those specimens wherein the proportion of magnesia is small, the high percentage of nickel (39) present in nepouite is another characteristic by which it may be distinguished from garnierite and noumeite. L. L. B.

PARAVIVIANITE AND KERTCHENITE, TWO NEW MINERALS.

Ueber zwei neue phosphorhaltige Mineralien von den Ufern der Strasse von Kertsch. *By* S. POPOFF. *Centralblatt für Mineralogie, Geologie und Paläontologie*, 1906, *pages* 112-113.

These minerals occur among the limonite-ores of the peninsula of Kertch and Taman, in the far south of Russia.

Paravivianite, in transparent, acicular, bluish crystals, has a specific gravity of 2·66 to 2·67, hardness somewhat over 2, and yields a bluish streak. It corresponds in composition to the chemical formula: $(Fe\,Mn\,Mg)^3\,P_2\,O_8 + 8\,H_2\,O$, contains 39·12 per cent. of ferrous, but no ferric oxide, 27·01 of phosphorus pentoxide, and 2·01 per cent. of manganous oxide.

Kertchenite is in the form of flat tabular crystals arranged in fibrous radial aggregates, dark-green verging on black, has a specific gravity of 2·65, hardness 3·5, and yields a green streak. It corresponds in composition to the chemical formula: $(Fe\,Mn\,Mg)\,O . Fe_2\,O^3 . P_2\,O_5 + 7\,H_2\,O$, and contains, on an average, 32·93 per cent. of iron peroxide, 9·49 of ferrous oxide, 28·2 of phosphorus pentoxide, and 1·92 of manganous oxide. L. L. B.

YTTROCRASITE AND PARATACAMITE: TWO NEW MINERALS.

(1) *Über Yttrocrasit, ein neues Yttrium-Thorium-Urantitanat.* *By* W. E. Hidden *and* C. H. Warren. *Zeitschrift für Krystallographie und Mineralogie*, 1907, *vol. xliii., pages* 18-23; *and*

(2) *Über Paratacamit, ein neues Kupferoxychlorid.* *By* G. F. Herbert Smith. *Ibid., pages* 28-35, *with* 5 *figures in the text.*

The crystalline mineral to which the name yttrocrasite has been given was found in Burnet County (Texas), among the waste-material thrown out from a gadolinite-digging, in rocks where granular granite and pegmatite are conspicuously abundant. The fresh mineral is black with a resinous lustre, uneven and slightly conchoidal fracture, of hardness ranging between 5½ and 6, and specific gravity 4·8. Careful analyses showed it to be essentially a hydrated titanate of thorium and the yttrium-earths. A study of its radio-active properties confirmed the results of the chemical analyses in regard to the percentages of uranium (2·29) and oxide of thorium (8·75) contained in it.

Paratacamite is a pale bluish-green crystalline mineral, which has been obtained chiefly from the Herminia and Generosa mine in the Sierra Gorda (Chile); one specimen, however, got from the Boluco mine, Labrar, also in Chile, occurred in association with gold. Other associates are galena, caracolite and quartz. Crystallographic examination shows that its optical properties do not coincide with its symmetry; and its double refraction is so feeble, that, when looked at through a prism, it appears to be singly refracting. It is a hydrated oxychloride of copper, of the same empirical formula as atacamite, namely: $Cu\,Cl_2.3\,Cu\,(OH)_2$. Chemical analysis yielded the following results:—Copper monoxide, 56·10 per cent.; copper (additional), 14·27; chlorine, 15·97; and water, 14·10. The mineral is brittle, has a conchoidal fracture, a glassy lustre, and a green streak: its hardness=3, and its specific gravity=3·74. L. L. B.

DETERMINATION OF GOLD IN AURIFEROUS SANDS.

Note concernant la Recherche de l'Or par la Voie humide dans les Sables aurifères. *By* Albert Fournier. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1907, *vol. cxliv., pages* 378-381.

Having occasion to examine some auriferous sands, the author was led to use the wet method of analysis. The material was highly ferruginous, and it was needful to avoid the presence within the same solution of dissolved gold and of comparatively large quantities of other metals, iron in particular. It is hardly necessary to emphasize the extreme difficulty that attends the determination of very minute quantities of gold, when present in solution with a much larger proportion of iron. Now, it seemed a logical proceeding to attempt to leach out the oxides of iron by means of hydrochloric acid, to which gold is generally refractory; and then to extract the gold by means of *aqua regia*. But this method, systematically applied to the sand in question, yielded no tangible result; nor did the direct application of *aqua regia* prove more successful. The key to the mystery was furnished by the presence of peroxide of manganese, which indirectly promoted the solution of the gold by hydrochloric acid, on account of the liberation of a sufficient quantity of chlorine in the nascent condition.

This being ascertained, the author now adopts the following method of determining gold in manganiferous material. To the manganese (peroxide probably) present, he adds 5 to 10 per cent. of manganese dioxide known to

be free from any trace of gold; and, after mixing the material well together, he treats it with cold concentrated hydrochloric acid for 24 hours. Then he places it in the sand-bath, until the liquid, previously red and blackish, becomes perfectly clear. After decantation and washing with acidulated water, he places the material in the sand-bath until it assumes a pasty consistency when hot; although by this time it has lost most of the hydrochloric acid, the mass still remains very acid; then he precipitates it, still hot, in a sufficient quantity of alcohol which is at a temperature of 203° Fahr. After being well shaken up, allowed to rest for 48 hours, then filtered by decantation, the resulting alcoholic solution contains all the chlorides that are soluble in alcohol. It is then placed over the sand-bath, and a current of pure sulphuretted hydrogen is passed through, for a time the length of which depends on whether the assayer wishes to determine metals whose sulphides are insoluble under the stated conditions. Starting originally with, say, 7 ounces avoirdupois of sand, the experimenter will need to pass the current through for 5 or 6 hours uninterruptedly; with a little over 2 pounds, the time required is 12 hours, and so on in proportion. The insoluble sulphides are washed first with slightly chlorhydrated boiling water, then with pure boiling water until the action of nitric acid is negative. The sulphides are thereafter treated in the sand-bath with pure hydrochloric acid, free from all traces of nitric, washed, again treated with hydrochloric acid to which this time a few drops of nitric are added, evaporated to dryness, twice again treated with hydrochloric acid, and then washed. The solution of precious metals thus obtained may be reprecipitated by means of sulphuretted hydrogen, if it is feared that traces of iron are still present.

Stress is laid on the advantages accruing from the use of alcohol in this process, as also on the certainty of the results obtained, provided that a sufficient mass of material is dealt with. L. L. B.

MANGANESE-ORES.

Die Deckung des Bedarfs an Manganerzen. *By* WILHELM VENATOR. *Stahl und Eisen*, 1906, *vol. xxvi., pages* 65-71, 140-150 *and* 210-217, *with* 12 *figures in the text and* 2 *plates.*

The recent political disturbances in Russia have brought about a considerable diminution in one (perhaps the most important) of the sources of supply of manganese-ores, and it is hardly necessary to point out that this circumstance must cause some anxiety to steel-producers. The author, in giving a synopsis of manganiferous deposits all over the world, hopes to be of some assistance in directing attention to possible new sources of supply.

It is only within the last 20 years that manganese-mining has attained anything like its present development. In the glass and gold-industries, the richer and purer manganese-ores, containing a certain minimum of the peroxide, alone are utilized; but the amount thus absorbed is infinitesimal in comparison with the requirements of the iron-and-steel industry. In the metallurgy of iron and steel, two principal varieties of manganese-ore are used: (1) manganese-ores containing about 50 per cent. of the metal, and but little phosphorus and silica; and (2) manganiferous iron-ores, with extremely variable percentages of manganese. Now, it is estimated that in 1902, the world's output of manganiferous ores amounted to 1,502,400 tons, a total including some very low-grade ores; whilst the total amount of 50-per-cent. ore used up in the iron-and-steel industry must have exceeded 907,000 tons. In regard to output of ore, the statistics show very considerable increases

for Russia (until recently), Brazil, India, and Cuba, while the output has remained practically stationary in the United States, Prussia, Spain, Austria, and Italy. The importance of Russia as a factor in the world's supply may be gauged from the figures of her output of manganese-ore in the year 1900; namely, 884,200 tons. She seems to possess practically a monopoly of high-grade ore, and (given political tranquillity) her output seems to be still capable of enormous expansion. It is true that the methods of working, in the Caucasus, for instance, leave much to be desired; it may be inferred that they are both primitive and wasteful. The amount of manganese-ore in sight in the Caucasus is estimated at 98,000,000 tons, and in the Nicopol district of Southern Russia at 40,000,000 tons; no statistics are forthcoming in regard to the other districts.

Germany is by no means poor in manganiferous deposits, but the output from the different mines is comparatively small. The extreme irregularity of the deposits, however, is an element of risk which the prudent capitalist must needs take into account.

Turning then to the consideration of the mining of manganese-ores, the author remarks that this is a subject of not very absorbing interest for the practical miner, as the almost universal conditions of the deposits are such that underground or deep-level workings hardly come into account. It is true that in the Caucasus there are some underground workings, where the deposits have a seam-like character; but even these can generally be reached by adits opened up in the hill-sides. In Brazil and India, the deposits lie so near the surface that the conditions are extremely favourable for open-cast working. The author reproduces several photographs of Indian, Turkish, and Caucasian mines, and tabulates 96 chemical analyses (previously published by various authors) of Russian, Italian, Spanish, French, Brazilian, Chilian, Indian, Japanese, Panama, United States, Bosnian, and Greek ores. With regard to the geological characteristics of manganiferous ore-occurrences, the reader is referred to Mr. Léon Demaret's great memoir on those deposits.*

A catalogue is then given of the most important occurrences throughout the world, the whereabouts of which are indicated on the two maps that accompany the paper; and the author concludes that the necessary supply of manganese-ores for the iron-and-steel industry of all countries is assured for a long time to come. The Caucasus alone could furnish the necessary million tons or so for another century; and to this may be added the output from other parts of Russia, from Chile, Brazil, and India. A bibliographical list is given of the publications of which use has been made in the compilation of this paper. L. L. B.

KARÁCS-CZEBE GOLD-MINES, HUNGARY.

Die Goldgruben von Karács-Czebe in Ungarn. By Karl von Papp. *Zeitschrift für praktische Geologie*, 1906, *vol. xiv., pages* 305-318, *with* 5 *figures in the text.*

South of Körösbánya in Hunyad county, the Magura and Karács hills are girdled round with auriferous deposits which were at one time successfully mined, but are now in such a state of abandonment that most of the workings have fallen in. In the summer of 1905, in the course of his geological survey of the district, the author had an opportunity of personally investigating these deposits, partly with the view of determining whether they really constitute the choicest morsel of the Transylvanian gold-belt, and

* *Annales des Mines de Belgique.*

whether consequently the resumption of mining operations would prove feasible.

It is necessary to clear one's mind of Dr. F. Pošepny's postulated triangle of gold-mines in this area: as a matter of fact, the Transylvanian gold-bearing district covers an irregular quadrilateral, the respective angles of which are determined by the four localities, Offenbánya, Zalathna, Nagyág, and Karács. Outside this quadrilateral, Transylvania can boast of no existing or prospective gold-mine of any consequence. The oldest formations in the district are a dirty-green melaphyre and a flesh-pink quartz-porphyry, with which are associated tuffs scarcely to be distinguished from the solid rock, all of Triassic age. On the whole, they are not rich in metalliferous ores: nevertheless, pyrites occurs in them at Kazanesd and Felvácza, and also valuable copper-ores at Almásel. In some places, reef-limestones of Jurassic age rest upon these rocks, and are in turn succeeded by the Carpathian Sandstones of Cretaceous age. The sandstones are overlain by red clays and coarse-grained drifts, which form the floor of the Miocene brown-coal deposit. The summits of Karács (2,750 feet) and Magura (2,493 feet) are built up of andesitic lava-flows which date from Miocene and Sarmatic times. Later on, the fumaroles and solfataras of the decrescent phase of vulcanicity silicified and altered the rocks, while ores were deposited in the fissures. This process of deposition appears to have occupied a considerable interval of time: at all events, the deposits of gold and other noble metals were being formed, from the Sarmatic period onward into Pontic or Pannonian time. The Karács rock is predominantly hornblende-andesite, in part weathered to kaolin: and the gold-mines have been opened up in a mighty angular breccia of andesite and dacite-fragments.

Here occurs the famous lode of Czebe, which is probably a gigantic fissure-vein. It was the belief of the old miners that the lode is richest near the surface, and that there is progressive impoverishment in depth; this, however, has proved untrue of the neighbouring Ruda mines, and, although the deep-level adit at Czebe has not as yet yielded workable ores, there is some reason to think that it will do so when driven for the proper distance into the hill. The gold occurs in a rusty-red plastic china clay, raddled by limonite and manganese-ores. It is rarely in the free state; among the associated minerals are sylvanite (telluride of gold and silver), nagyágite (tellurisulphide of lead and gold), pyrites, galena, blende, rhodochroisite, etc.

The usual agencies of erosion have heaped up coarse gravels in the Körös valley, among which gold-dust is disseminated, and that most abundantly where the elements of the gravel are coarsest. Of this fact, the ancient Romans were not unobservant, and traces of their industry are still noticeable at the confluences of streams where the gold-bearing alluvial fans spread out. But the gold-mining industry of the region dates much further back even than the Roman dominion. The author sketches briefly the history thereof down to recent times, and reckons that 401,875 ounces of gold, in all, were got in the district during a period of 2,000 years. He also describes seven abandoned mines, and estimates the gold that might still be got from them and from the alluvia as amounting to 113,000 ounces. In regard to future working, the essential procedure would be to drive a deep-level exploration-adit, using for that purpose the Rosenfeld adit, which has already been driven 1,518 feet, but caved in several decades ago. A sufficient water-supply for mining purposes for a 3- to 6-stamp battery would be permanently available by utilizing the waters of the Körös stream, some 3¾ miles distant.

L. L. B.

MINERAL INDUSTRY IN RUSSIAN CENTRAL ASIA.

Das Berg- und Salinenwesen in Russlands mittelasiatischen Besitzungen. By F. THIESS. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussischen Staate*, 1906, *vol. liv., Abhandlungen, pages* 189-197, *with* 3 *maps in the text.*

The provinces of Transcaspia, Samarkand, Ferghana (including the Russian Pamir), Syr-Daria, Semiryetshensk, and the two vassal states of Khiva and Bukhara, cover an area of close upon 790,000 square miles, and are now all included in the designation "Russian Turkestan." This region, which is as big as the German and Austrian Empires, France, Italy, and Denmark put together, extends for some 1,660 miles from south-west to north-east, and its greatest breadth is 930 miles (from north to south). The greater portion consists of sandy desert with artificially-irrigated oases, loam- and lœss-covered steppes, and pasturages with salt-marshes, the greatest depressions being 147½ feet below the level of the Caspian, and the highest undulations in the Turkestan plain attaining an altitude of 1,000 feet above the level of the same inland sea. Apart from this, however, a quarter of the entire area is mountainous, being traversed in the south-east, east, and north-east by ramifications of the Tian-Shan and Alaitagh ranges.

The great Central Asian railway, 1,570 miles long, traverses the entire region, and is now linked up with the railway-system of Russia-in-Europe by means of the Orenburg-Tashkent line. With the construction of the railway has coincided an active investigation of the mineral resources of the country on the part of its new masters; and the foundations have been laid for an industry on modern lines, in lieu of the present, generally primitive, method of conducting mining operations in that part of the world.

Beginning with the province of Transcaspia, 88 per cent. of the 233,575 square miles which it occupies is desert, the remaining 12 per cent. being arable land. Brown-coal is known to occur in the Mangishlak peninsula in the far north-west and on the Tuar-kir heights in the district of Krasnovodsk. Sulphur occurs in various localities, and has been worked by the natives in the Kara-Kum desert, where bands of sulphur of variable thickness are interbedded with the Tertiary marls in certain isolated hills. Brown hæmatite has been proved in the Kara-tau mountains on the Mangishlak peninsula. The salt-lakes are of considerable importance, yielding besides rock-salt what is in Russian called *samosadótshnaya solye* (self-separated salt) from deposits in actual course of formation along their edges. The total output of salt from the province in 1901 amounted to 16,638 tons, whereof 12,495 tons came from the great rock-salt deposits of Tsheleken island, only 323 from Balla-Ishem (where, however, there are 3½ million tons of rock-salt in sight), and 3,820 tons of "self-separated salt" from the salt-lakes. The Glauber-salt deposit at the bottom of the shallow Kara-Bugas gulf increases in thickness by 0·4 inch every year: it is said to cover an area of 1,235 square miles, and the quantity of available mineral is estimated at several million tons. Since 1901, the deposit has been worked by private enterprise, and detailed information is not forthcoming.

Even before the Russian conquest, the Turcomans tapped for domestic purposes the natural oil-wells in the Nafta-Dagh and the Buja-Dagh; from the former range the railway-station of Balla-Ishem is only 20 miles distant, and so the Russian engineers in 1882 tapped springs of petroleum at depths of 400 to 550 feet, and made use of the oil for driving the locomotives and lighting and heating the stations along the line. Since then, fresh oil-wells have been

tapped in the same locality. The petroleum-deposits on the Island of Sheleken are actively worked, and the oil is sent in tank-steamers to the Baku refineries. In 1902, the total output of crude petroleum from Transcaspia amounted to 10,500 tons (say, 2,311,000 gallons). Asphalt-deposits are known to occur in the Balkhan-Dagh, gypsum in the neighbourhood of Krasnovodsk, and many thermal springs are visited throughout the province for their curative properties. Limestone is quarried in the Kopet-Dagh and other localities.

In the province of Samarkand, bituminous coal has been proved at a score of localities at least, and in a dozen instances these are not far from the railway. Among other minerals may be mentioned anthracite, graphite, calamine, antimonite, ores of lead, copper, and manganese, native sulphur, and turquoises. Five coal-mines are at present in operation, but their total output in 1901 amounted to barely 8,000 tons. The fissuring of the strata is one of the great difficulties with which the Samarkand miner has to contend; and it must be remembered that the rule is to work only for the first five months of the year, although one or two mines are at work all the year through. The coal is taken, over very bad roads and bridle-paths, by pack-camels to the centres of population. The miners' wages average 1s. 6d. *per diem*, the prime cost of the ton of coal ranges as high as 13s., and the freight, etc., may amount to 26s. per ton. In Tashkent itself in 1895 the retail price amounted (for small quantities) to as much as 52s. 6d. per ton of coal, and in Khodshent (one of the coal-districts) to 31s. 6d.

Bituminous coal is found in every district of the province of Ferghana, except that of Osh. Anthracitic and graphitic deposits occur in the Karategin-Dagh. Placer-gold is found in the Muk-su torrent, and the primary auriferous deposit is suspected to occur in the narrow and hardly accessible ravine of Saok-sai, whence the Muk-su issues. Petroleum, rock-salt, and lake-salt are found in many localities, and cinnabar, sulphidic ores, and various ores of lead, copper, and iron are of fairly widespread occurrence. Copper-ore, containing as much as 60 per cent. of the metal, was discovered in 1905 at Naukat on the Syr-Daria, and smelting-works are now being erected there. Three sulphidic ore-mines are worked in the district of Khokand, and one coal-mine in that of Namangan. The salt-output from the province in 1901 amounted to 11,466 tons. The numerous occurrences of petroleum can be traced to two distinct belts—a north-easterly extending some 26 miles through the districts of Namangan and Andishan, and a south-westerly extending no less than 66 miles through the districts of Marghelan and Khokand. In many places mining operations have begun only as recently as 1905.

In the Syr-Daria province, the occurrence of coal, lead, copper, and iron-ores has been proved. Only one coal-mine is at present worked, in the Kara-tau mountains of the Tshimkent district: the comparatively insignificant output, 300 tons or so *per annum*, is used for heating the Government buildings in the city of Tashkent, and for industrial purposes. Rock-salt and lake-salt occur in many localities; but the deposits are almost exclusively worked by the natives, the annual output amounting to 3,000 tons or more.

The province of Semiryetshensk is, for the greater part, mountainous country, and but little prospecting work for useful minerals has been accomplished therein so far. The occurrence, however, of coal, graphite, gold, lead- and copper-ores, rock-salt and lake-salt, etc., is more or less established, although in many cases the unconfirmed statements of the Kirghizes constitute the only available data. L. L. B.

WORKING OF NATIVE SULPHUR IN SICILY AND IN LOUISIANA.

Note sur les Conditions économiques de l'Exploitation du Soufre en Sicile et en Louisiane. *By* L. Aguillon. *Annales des Mines*, 1906, *series* 10, *vol. x.*, *pages* 599-617.

The sulphur-industry in Sicily, which until recently, so to speak, could lay claim to the production of 90 per cent. of the world's output of sulphur, was, from the year 1860 until 1883 in a phase of continuous development. Since the last-named year it has been subject to frequent and considerable oscillations. After a period of depression lasting until 1890, there was in that and in the following year a short interval of long-unexampled prosperity, succeeded in 1893 to 1895 by a continuous fall in prices such as to make the greater number of the sulphur-mines economically unworkable.

Apart from a few large estates, landed property in Sicily is cut up into innumerable small holdings, and the right of quarrying the sulphur is attached to the ownership of the surface-soil. But the small landholder, as a rule, is no prospector, nor does he attempt to work the mineral-deposits which may occur on his property: he prefers, indeed, to let someone else work them on payment of a royalty (*estaglio*) equivalent to 15 or 20 per cent., or even more of the gross output. The mines are usually of very small extent, and this limitation of area is a hindrance to rational methods of working. The number of such mines increased from 480 in the year 1890 to 777 (actively at work) in 1905, in which year the total output amounted to 535,782 tons; but the output from 679 of these workings averaged rather less than 200 tons apiece. The lessees who work the smaller mines borrow the necessary funds, at an exorbitant rate of interest, from the warehousemen with whom they deposit their sulphur as security. One per cent. of the sulphur also goes to the warehouseman in lieu of rental, and there are other onerous conditions which justify the author in characterizing the system as usury naked and unashamed. The consequences, to the lessees and the 40,000 work-people employed in the mines, are disastrous at times of low prices; as in 1895, when the Italian Government, by way of palliative measures, suppressed the export-duty and granted a fixed bounty on every ton of sulphur shipped. Yet even this would have been inadequate, but for the constitution in 1896, at the worst of the crisis, of a strong British company which, by an agreement with the Italian Government, undertook to purchase, at a fixed price according to quality, all the sulphur produced in Sicily. This resulted immediately in a rise of prices, and in the liberation of the sulphur-producers from the toils of usury. The Company prospered exceedingly, paying dividends of 50 per cent. on the ordinary shares, but was wound up on July 31st, 1906, at the termination of its second quinquennial agreement. The stock of sulphur which it had then on its hands was practically equivalent to the output of a whole year; the annual output, by the way, had continuously increased from 353,000 tons to 535,782 tons in 1905.

Silician sulphur had now met with a formidable rival in the world's markets, in the shape of the mineral from Louisiana, and the once considerable export to North America had dwindled to half its former amount within three years. The Italian Government thereupon promulgated the law of July 15th, 1906, which, from the date of the ensuing first of August, constituted a legally compulsory syndicate of the owners, lessees, and workers of all the sulphur-mines in Sicily then existing or thereafter to be opened up, for the space of twelve years. The syndicate alone is empowered to place sulphur on the market, and the mineral can neither be carried by railway, nor shipped by

sea, without a permit from the syndicate. Infractions of the law are punishable by the criminal, as well as by the civil code. This law applies, of course, to the crude sulphur (*solfo grezzo*) alone: the industries that are concerned with the refining, grinding, and subliming of sulphur, remain unaffected by it, but they have to purchase the raw material from the syndicate.

Various supplementary provisions are explained, such as the constitution of a benevolent fund for the benefit of those who would be thrown out of work by a reduction in output; the measures for dealing with the stock inherited from the British company, and for the fulfilment of contracts previously entered into for future delivery. Details are given as to the administrative council, headed by a director-general nominated by the King of Italy, and the committee of delegates of 50 members, who conduct the affairs of the new syndicate. By means of a temporary royal commission, consisting of only five members, the transition from the old *régime* to that now in force was accomplished without a hitch. Careful arrangements were made in regard to finance, warehousing, remission of burdensome taxes, etc.; nothing, in fact, was omitted in this legislation, for which an analogy would be vainly sought in any other country. Admitting that the new law apparently contravenes most of the old-established principles of liberty of contract, freedom of labour, rights of property, etc., the author points out, on the other hand, that the circumstances of the Sicilian sulphur-mining industry are so very exceptional, that they justify such an heroic remedy as the drastic intervention of the State sanctioned by this law.

The deposit of native sulphur which is now being worked in the great coastal plain of Louisiana occurs at the base of the Miocene, in a group of clays and sands, which also yield gypsum, natural gas, and petroleum, in the parish of Calcassieu, 11 miles or so west of Lake Charles, and 15½ miles distant from the Sabine river, which forms here the boundary between Texas and Louisiana, and is navigable by sea-going vessels. It was in the course of boring for oil that, in the year 1868, a bed of pure crystallized sulphur, 105 feet thick, was struck at a depth of 436 feet from the surface. Later on, endeavours to sink a shaft to this bed by the Kind-Chaudron process were defeated, as it was found impossible to get through the quicksands and water-bearing beds. Meanwhile new borings revealed the existence of other masses of native sulphur, the total amount of pure mineral in sight being then estimated at 3,000,000 tons.

Thereupon, in the year 1895, a syndicate was formed to work the deposits by means of the Frasch process. This consists essentially in melting the sulphur *in situ*, by injecting through a boring, carried down to the floor of the deposit, water heated to 334° Fahr. at a pressure of 16½ pounds per square inch, and in bringing the molten sulphur to the surface by blowing into it air compressed at 28 atmospheres, in such wise that the specific gravity of the ærated column of sulphur is less than that of the descending column of superheated water. The water is injected in an external column, the sulphur ascends in an internal column, and the compressed air descends in an intermediate column. At the surface, the sulphur flows into great reservoirs built of wooden planking; and, when solidified, the mass is broken up into portions suitable for shipping. It is only since 1903 that the process, after repeated and costly trials, has become industrially applicable on this great scale. Meanwhile, the true extent of the sulphur-deposits has been more definitely ascertained: over an area of at least 64 acres, below from about 490 to 625 feet of barren covering strata, they form on the whole a practically horizontal mass varying in thickness from 200 to 330 feet, and may amount

to 40,000,000 tons (as compared with 54,000,000 tons, the total estimated mass of the native sulphur-deposits of Sicily). The local conditions are favourable to the working of the Frasch process, which consumes an enormous amount of steam. Petroleum for oil-fuel is obtained very cheaply from Beaumont in Texas, not 50 miles distant; and water is brought by a canal, $3\frac{3}{4}$ miles in length, from the Houston river, a tributary of the Calcassieu. Three bore-holes are worked simultaneously, about 100 feet apart; the installation and putting down of each bore-hole, everything included, costs from £520 to £840, and can be completed in a month. The sulphur obtained by this process is remarkable for its purity. L. L. B.

GOLD AND SILVER-MINES OF ARZATE, MEXICO.

Reseña del Mineral de Arzate (Estado de Durango). *By* Juan D. Villarello. *Memorias de la Sociedad científica "Antonio Alzate," 1905, vol. xxiii., pages 211-239.*

The Arzate metalliferous deposits, upon which exploration-work was first re-started in the course of 1899, occur in the sierra of the same name, in the commune of Pámeco, department of San Juan del Réo, State of Durango, in the neighbourhood, more or less remote, of several other metalliferous occurrences which were actively worked in the days of the Spanish overlordship.

The geology of the sierra is simple enough, as there are no outcrops of sedimentary strata, and the range is built up mainly of pink rhyolites showing fluidal structure, of Pliocene age, overlain by vast basalt-flows dating from the Pleistocene. Three systems of fissures traverse the rhyolites, and some of them are mineralized, forming lodes of extremely variable thickness. The outcrops of these lodes are marked by gossans of quartz and iron-oxides, with which is associated a small quantity of native gold; but both lodes and gossans are entirely cut off by the Pleistocene basalts.

The workings of the Independencia mine have opened up a vein wherein the metalliferous ores form small, irregularly dispersed lenticles, the industrial value of which diminishes as the depth from the surface increases. For, although the quantity of silver contained in the ores augments proportionately with the depth, that of gold correspondingly decreases: thus, the stuff got from the upper portion of the workings yields 1·6 ounces of gold and 2·56 ounces of silver per ton, while that from Hidalgo shaft yields only 0·256 ounce of gold, but 5·6 ounces of silver.

North-east of the Independencia mine is the Libertad mine, working a lode which strikes parallel with that opened up in the former mine. Its thickness at the surface measures 20 inches, but diminishes in depth until from 65 feet downward it is just 0·8 inch. The vein is mineralized with ferruginous quartz, oxides of iron, a small quantity of pyrite, native gold in granules, etc., and a very small amount of embolite (chlorobromide of silver); these, as in the previously-described case, occur in irregularly dispersed lenticles of no great size, which are perhaps, if anything, of less industrial importance than the metalliferous lenticles of the Independencia mine.

The northernmost mine hereabouts, that of La Cruz, has opened up a lode about 12 inches thick, yielding on assay 0·16 ounce of gold and 2·43 ounces of silver per ton.

The author explains at some length his reasons for not regarding these lodes as true fissure-veins: he classifies as the primary minerals therein the rather sparsely distributed pyrite and the quartzose gangue; as secondary minerals (due to the downward percolation of surface-waters), the hydrated oxide of iron, the small quantity of native gold, and the minute percentage of

embolite. As to the age of the lodes, from what has been already stated it follows that they were formed subsequently to the consolidation of the rhyolites and before the eruption of the Pleistocene basalts; in fact, they probably date from the late Pliocene. It seems probable that, when the underground water-level of the country is reached by the mine-workings, the zone of the original sulphides will be simultaneously reached; and therewith the various silver-bearing ores will be found in the lodes, but containing still less gold than the portions already explored.

The question of the origin of these deposits is discussed at great length, and in a general classification which the author proposes he ranks them as magmatogenic and catamorphic, that is, formed by the elimination of aqueous constituents (dishydration) from the deep-seated portion of the magma which produced the rhyolites, and mineralized by metasomatic substitution. The very unequal thickness of the lodes and the frequent indefiniteness of the boundary between them and the country-rock favour the metasomatic hypothesis. It remains to be said that the deposits are situated some 10 miles to the north-west of the Gabriel station on the International Mexican Railway, and that the water-supply of the district is scanty—consumers being mainly dependent for this article of necessity on rain-water tanks. L. L. B.

METALLIFEROUS MINES OF ZACUALPAN, MEXICO.

Descripción de algunas Minas de Zacualpan (Estado de México). *By* Juan D. Villarello. *Memorias de la Sociedad científica "Antonio Alzate,"* 1906, *vol. xxiii., pages* 251-266.

These mines are situated in very rugged country in the Sultepec district of the State of Mexico, some 37 miles south of Toluca, the capital city of that State. The exploration and working of the deposits date back as far as the early days of the Spanish conquest, while fresh finds as recently as 1897 momentarily galvanized into life the ancient mineral industry of the region, and for three years thereafter a vast quantity of rich ore was got and sent off from Zacualpan.

The rocks of the country consist (1) of black or bluish-grey Cretaceous shales, both argillaceous and calcareous, occasionally metamorphosed into apple-green chloritic schists, striking north and south and almost horizontally bedded; and (2) of intrusive hornblendic andesites of Tertiary age, which cut across, invade, and metamorphose the above-described sedimentaries. All the rocks alike are traversed by three distinct systems of fissures, none of which have caused sufficient dislocation to be regarded as true faults. They extend from Zacualpan through Chontalpa and Pregones, towards Noxtepec and Taxco, and throughout that vast area many of the fissures are richly mineralized—the principal ores being pyrargyrite, argentiferous pyrite, galena, zinc-blende, etc., of the primary infilling; and oxides of iron, native silver, and argentite, the outcome of the secondary differentiation of the infilling, these latter being known locally as *ixtajales*. The gangue is either predominantly quartz or predominantly calcite, more often the former.

At El Moral mine, the best-known lode is the San Miguel, striking generally 50 degrees north-west, dipping north-eastward, averaging 3¼ feet in thickness, and well marked off from the hornblendic andesite through which it courses. Its mineralization varies with the depth: thus, from the surface down to the first level, argentiferous galena occurs in small quantity, while pyrargyrite and amorphous pyrite are abundant; between the first and the second levels, argentiferous galena abounds, the percentage of silver increasing concurrently with the depth, while pyrargyrite and pyrite are

scarce. The ores occur within the quartzose-calcitic gangue in the form of long thin lenticles, locally termed *botones*, the most extensive lenticle yet discovered measuring 174 feet from the surface downwards (which represents the greatest depth as yet reached by the workings). The San Carlos lode, striking between 20 and 30 degrees north-west, and dipping north-eastward, also traverses the andesite. It is of extremely irregular thickness, often trailing out into mere stringers, while occasionally it broadens out to over a yard. The gangue is predominantly calcite, with a little quartz; irregularly dispersed within it are masses of pyrite and argentiferous blende. Deeper down, galena makes its appearance, while the previously-mentioned ores are occasionally found concentrated in small lenticles. East of the San Miguel, three other parallel veins bearing similar ores have been the object of exploration-work; while those to the west of the lode had not yet been prospected at the time of the author's visit.

In La Providencia mine, four lodes traversing the argillaceous shales contact-metamorphosed by the andesite, have been prospected: they vary in thickness from 2 inches at the surface to 4 inches at the greatest depth yet investigated, and consist of quartz mineralized with argentiferous galena and a small quantity of auriferous pyrite.

At La Reforma mine, three lodes, similarly traversing the metamorphosed shales, contain pyrargyrite, pyrite, and argentiferous galena, irregularly disseminated in a gangue of quartz. In thickness they vary between 20 and 28 inches, and, in what the author terms the "lixiviation-zone" or zone of leaching, occur the secondary ores, the *ixtajales* (oxides of iron, with a little native silver and argentite). Two of these lodes strike north and south, being intersected by the third, which strikes 15 degrees north-east; and enrichment occurs at the points of intersection. One gathers that these ores have been largely worked out.

Considering that the above-mentioned lodes cut through the Tertiary andesites as well as the Cretaceous sedimentaries, they must be younger than the former, and probably date from the Pliocene period. It has already been mentioned that the lenticles of metalliferous ore are met with continuing from the surface downwards to great depths, the percentage of silver increasing concurrently with the depth. But lower down than 500 feet, impoverishment sets in, the infilling becomes almost exclusively quartzose; and, on this barren horizon being reached, exploration-work was stopped.

The author regards these mineralized fissures as due to the dynamic effects of pressure, the more so as they appear to form conjugate systems: that is, they strike on the whole parallel one to the other, with contrary dips. No characteristically contact-metamorphic minerals are found in the infilling, or in the immediately contiguous "country-rock," which is merely silicified (in places) adjacent to the lodes. These were probably infilled by metalliferous particles derived from the thermal waters percolating upwards through the rocks; but metasomatic replacement also played a part in the infilling.

The picked ores got from the San Miguel lode yield on an average 10 to 20 per cent. of metallic lead and 58 ounces of silver per ton. Those from the San Carlos lode, after sorting, yield from 26 to 32 ounces of silver per ton; and those from La Fortuna mine, the workings of which are flooded and have caved in, yielded (after sorting) from 32 to 96 ounces of the precious metal per ton.

Generally speaking, the local conditions are such as to favour the economic development of a mineral industry. L. L. B.

USE OF EXCAVATORS AT THE BROWN-COAL MINES OF PRUSSIAN SAXONY.

Die Verwendung von Baggern zur Abraumarbeit auf den Braunkohlenbergwerken der Provinz Sachsen. By M. TORNOW. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussischen Staate*, 1906, *vol. liv., pages* 568-595, *with* 5 *figures in the text.*

The recent enormous development of the German brown-coal industry is exemplified by the official statistics issued for the mining district of Halle, which show that the annual output for that district has increased from 9 million tons (in round figures) in 1880 to 34 million tons in 1905. This development has been especially marked within the last decade in Central Germany, and here the fierce combat which producers have to wage with their Bohemian rivals (one of the incidents of the struggle being a continuous decline in prices for the past quarter of a century), makes the smallest economy in working a factor of vital importance.

During the fifteen years that have just elapsed, the Central German opencast workings have reached the phase of enterprises conducted on a colossal scale, some of them being $\frac{3}{5}$ mile in length and more. The older method of quarrying, still pursued in several localities, has largely given way to the system of removing the cover by means of excavators, the economic limit of the proportion of cover to brown-coal being 2 to 1. The removal of the cover by manual labour would now be too costly, the scarcity of this labour is too marked, and the necessarily restricted size of the tipping-wagons under such circumstances too small, to admit of success in the commercial struggle to which reference has already been made. The introduction of excavators has facilitated opencast working on a large scale, with the resulting advantages that industrial operations on such a scale always imply.

In the spring of 1906, about sixteen excavators were at work in the brown-coal mines of the Prussian province of Saxony. But the mere citation of this number is far from representing the extent to which use has been, and is being, made of these appliances: in many cases the cover has already been excavated off considerable areas, and in others the excavators are only brought into action at intervals. If the above-quoted number were doubled, this would perhaps convey a more accurate idea of the present state of affairs. The excavators are each capable of dealing with a minimum of 28,000 cubic feet of material in a 10 hours' shift; and, on an average, they deal with from 42,000 to 52,000 cubic feet in that time, while those of the latest type have been known to deal with 87,500 cubic feet of material. Shovel and scraper-excavators are not used at these mines, the most favoured type being a deep-working bucket-chain excavator. The maximum depth to which these work exceeds 52 feet, the motive power universally applied being steam at a pressure of 7 to 8 atmospheres. An engine of 60 to 80 horsepower is found suitable for such excavators as deal with 52,000 to 70,000 cubic feet of material in a 10 hours' shift. The engine works at high pressure, regulated by a throttle-valve, and there is consequently some waste of heat. As to fuel, ordinary briquettes (on account of convenience of stacking) are preferred by some mine-owners; while others make use of small coal or of brown-coal briquettes. The author utters a warning as to the feeding of the boilers with unpurified pit-waters; owing to the percentage of sulphur present in the brown-coal, these generally contain a certain amount of sulphuric acid. The guidance of the excavator, with its various levers, demands considerable skill on the part of the man in charge; in fact, it is on him that the full

development of the capabilities of the apparatus depends. The excavators run on two or three heavy rails; in the case of especially heavy machines, so-called Goliath rails are laid down, measuring from 5·4 to 5·8 inches in height, and weighing not far short of 100 pounds per lineal yard.

The excavated material is removed in tipping-wagons of 105 to 157 cubic feet capacity: a mine will use on an average forty to fifty of these, sufficient to make up two trains and allow of a reserve stock being maintained. Increasingly powerful locomotives (from 80 to 125 horsepower) are being run with these, on tracks of 2 to 3-foot gauge; the rails are almost universally 5·4 inches in height, and weigh rather more than 70½ pounds per lineal yard.

The most advantageous position for the tip-heaps, and the most expeditious methods of loading the wagons, despatching the trains, and tipping their contents, with the view of realizing the greatest possible economy in working, are considered by the author in some detail. He also describes the local conditions, which sometimes necessitate the preliminary labour of levelling the land-surface and clearing it of forest-growth.

With regard to the nature of the cover that has to be removed, it varies greatly from place to place: Tertiary beds are often wanting above the brown coal. In the western districts of Prussian Saxony, especially around Bitterfeld, the coal is overlain by a bed of (occasionally) extremely pure clay, which furnishes the raw material for a flourishing pottery-industry and attains a thickness of 13 feet. Over this comes a still thicker bed of highly arenaceous gravel, in which erratic boulders of considerable size are of frequent occurrence, topped by thinner bands of læss or sand, the total thickness averaging 40 to 50 feet. In the eastern districts of the province, on the other hand, the cover is mainly composed of very easily removable sands, in which boulders rarely occur. The boulders, as might be expected, constitute one of the chief difficulties with which the excavators have to contend; not only do they cause much waste of time, but also on occasion destructive damage to the buckets or to the chain.

The removal of the cover generally precedes by a little the winning of the brown coal. The mineral is usually laid completely bare, without (apparently) much regard for the risks arising from the possibility of spontaneous combustion by slow oxidation in the open, and from the possibility of the coal being set alight by sparks from the locomotives, etc. Mine-owners have, indeed, been advised to protect the brown coal by leaving over it a thickness of 20 to 40 inches of cover, but they universally fight shy of the inevitably resulting expenditure on removal by hand, enhanced in cases where the surface of the coal is uneven. It is customary, where a pumping-plant is available, to adopt the precaution of spraying the uncovered coal on hot summer-days, in order to keep it to a certain extent moist.

The author points out that the economic success of the excavator-system depends primarily on the avoidance of pauses. There must not be a moment wasted, all through the process: this naturally involves skilled superintendence and high-class labour, and even so is rendered by circumstances occasionally impracticable. As to costs, a long series of examples is set forth in full detail, and, taking all the available data into consideration, the author concludes that the prospects of a further development of the excavator-system are decidedly favourable. In fact, he regards that system as having already become an indispensable factor in the successful working of the brown-coal mines of Prussian Saxony. There is, moreover, an idea afloat of utilizing the excavators for winning the coal itself, as the toughness of the mineral is not sufficient to affect prejudicially their working any more than would,

let us say, a stiff clay. The possible comminution of the brown coal in the process of excavating would not be considered much of a disadvantage, as in many mines the entire output is manufactured into briquettes.

L. L. B.

DYNAMITE-EXPLOSION AT THE ZAPPENDORF BORE-HOLE, GERMANY.

Die Dynamitexplosion in dem Bohrthurme bei Zappendorf am 4. Mai 1906. By — Beyling. *Zeitschrift für das Berg, Hütten- und Salinen-wesen im preussischen Staate*, 1906, *vol. liv., pages* 671-675, *with* 1 *figure in the text.*

In the spring of 1906, a deep bore-hole, in search of potassium salts, was put down in a concession belonging the Krügershall Salt-mining Company, immediately south of Zappendorf station on the Teutschenthal and Salzmünde railway. Boring operations were attended with great difficulties, as, on account of the disturbed condition of the rocks, the boring-tool continually stuck fast. When this happened once again, at a depth of 708 feet, all the known technical methods of setting the tool free were unavailingly applied, and consequently the engineers resolved to blast it away with dynamite.

Experiments were made with a magneto-electric igniter, in order to determine whether it worked properly, and several fuses (coated over with wax to preserve them from damp) were prepared. The explosive selected was gelatine-dynamite I. The manager of the salt-mine and the Goverument district-inspector betook themselves on May 4th to the Zappendorf bore-hole, accompanied by two officials of the mine in charge of 5½ pounds of dynamite. The insulated copper-wires for the electric ignition having been duly set in place, the first attempt to cause a detonation in the bore-hole failed. It was assumed that the failure was due to a spoilt detonator, more especially as no difficulty was experienced in causing a second detonator to ignite above bank. The cylindrical galvanized iron receptacle in which the dynamite-cartridges were placed is described and figured; the space remaining vacant therein was stuffed with wadding to a depth of about 0·4 inch (1 centimetre). As the bottom cover seemed to sit loosely on the cartridge-filled cylinder, the manager, despite certain objections raised by those present, gave orders to solder it lightly. At the very moment when the man was applying the soldering-iron, the dynamite exploded, and four out of the five persons who stood immediately round were torn limb from limb; the fifth (the Government inspector) was so seriously injured that he died after a few hours' suffering in hospital. Several other persons, who had stepped a little aside before the explosion, were slightly injured.

Expert opinion (fortified by experiments, of which an account is given, made after the disaster) is in concurrence with the official report issued by the Mining Bureau of the West Halle district, in holding that the explosion was caused by the contact of the soldering-iron with the metallic cylinder. The heat from the former must have been conducted almost instantaneously through the thin metallic partition to the gelatine-dynamite, which is apt to decompose and explode at such a temperature as that which the soldering-iron had reached. The manager, who paid for his imprudence with his life, although quite right in stating that dynamite can be harmlessly burnt off while held in the hand, had overlooked the fact that this statement only holds good of small quantities of the explosive burning in an unconfined space, not of large quantities enclosed in a receptacle. L. L. B.

GRÉHANT FIRE-DAMP INDICATOR.

Note sur le Grisoumètre simplifié de M. le Professeur N. Gréhant. ANON. *Annales des Mines*, 1906, *series* 10, *vol. x.*, *pages* 570-573, *with* 1 *figure in the text.*

The fire-damp indicator devised by Prof. Gréhant, and first described by him in 1894, was, in its original form, somewhat cumbrous and needed very delicate handling, with the result that it was but little used in practice. But the instrument has been now so simplified as to make it very much more convenient to manipulate, and to render it more easily available for taking laboratory-samples from the atmosphere of fiery mines. In its present form, it consists of a cylindrical glass-bulb within which is soldered a platinum-spiral; by means proximately of two glass-tubes filled with mercury, and then, by gutta-percha covered copper-wires, the spiral receives the current flowing from a battery of ten accumulators. In the upper portion of the glass-bulb is a tap, by means of which the gas that is to be analysed can be turned into it; and into the lower portion of the bulb penetrates a long glass tube, graduated from the point of contact with the bulb, and communicating by means of india-rubber-tubing with a glass recipient (or reservoir) containing water, which can be raised or lowered by a rack-and-pulley arrangement. The bulb first described is itself immersed in a cylindrical recipient or jacket, through which water is kept continuously flowing, so as to maintain the temperature at a constant level throughout the experiment. The relation between the volume or capacity of a division of the graduated tube and that of the bulb having been determined, the bulb is filled with water, and the gas which forms the subject of analysis is introduced into it until the gas fills up the bulb as well as a suitable number of divisions of the graduated tube. Then the tap having been turned off, the movable reservoir is raised so that all the gas is forced back into the bulb, and the electric current is switched on until complete combustion of the methane formene [not hitherto mentioned in the original paper] has taken place—this implying about 400 passages of the current in 3 or 4 minutes. The operator waits for a few minutes, until the temperature in the bulb returns to its normal level; the gas is then brought back to atmospheric pressure, and the diminution in volume will indicate the percentage of contained fire-damp, on the assumption that this diminution is equivalent to twice the volume of methane contained in the mixture, in conformity with the equation expressing the combustion: $CH_4 + 4\,O = CO_2 + 2\,H_2O$. The size of the bulb and the graduations of the tube can be so arranged as to involve a reduction in volume of ten divisions of the graduated tube for a mixture containing only 1 per cent. of fire-damp; and this implies a sensitiveness amply warranting the use of the instrument in mining practice. It is suggested that a convenient and portable size of instrument is obtained by using a glass bulb of $2\frac{1}{2}$ cubic inches capacity, with a tube so graduated that 50 divisions represent a volume of $\frac{1}{4}$ cubic inch. The operator must beware of introducing into the apparatus any inflammable mixture, the explosive combustion of which would undoubtedly shatter the bulb.

This indicator differs from Prof. H. Le Chatelier's instrument chiefly in that the latter indicates percentages of fire-damp by means of variations in pressure (the volume being always reduced to the same value); whereas the former keeps the pressure constant while varying the volume, and is perhaps more easily manipulated on that account by comparatively uneducated persons, such as those in whose hands the instrument would sometimes (at all events) be placed in mining practice. The sources of error due to the solubility of carbon dioxide in water, and to the difference of temperature between the

ambient atmosphere and the water-jacket, are not of sufficient importance in practice to vitiate the records yielded by the Gréhant indicator.

L. L. B.

FIRE-DAMP EXPLOSION AT THE LIÉVIN COLLIERIES, FRANCE.

Explosion de Grisou aux Mines de Liévin. ANON. *La Revue Noire*, 1907, *vol. x., pages* 43-45.

On January 28th, 1907, about 9 a.m., an explosion occurred in No. 3 pit of the Liévin collieries, whereby three persons lost their lives. They were engaged in perfecting the arrangments for conducting mine-gases from a disused portion of the workings in the François seam to an experimental gallery, which is in course of completion near No. 3 pit, and the nearest man was about 400 feet away from the François seam when the explosion took place. It may be noted, by the way, that the Liévin collieries have the reputation of being the most fiery of any in the Pas-de-Calais. At first, there seemed to be a reversal of the ventilation, but this almost immediately resumed its normal course; the noise and shock of the explosion, however, caused a momentary panic throughout the workings, and a crowd speedily assembled at the pit-head, fearing that a catastrophe had occurred on a scale similar to that of Courrières collieries. The great precautions habitually taken in these Liévin collieries: water-spraying, separate ventilation for each district, whitewashing of the walls of the roadways, etc., largely account for the restriction of the disaster to a comparatively limited area. The bodies of two of the victims (engineers) were found with wounds in the head and broken limbs, but practically unscorched; the third (an overman) was scorched from head to foot, yet his safety-lamp was intact, while those carried by the others were considerably damaged. Nevertheless, it seems probable that it was the overman's lamp that started the explosion. His body was found about 2,000 feet away from the two others; he appears to have gone on in front of the engineers in their tour of inspection, and, having met with fire-damp, it is probable that he precipitately withdrew his lamp, of which the regulating-screw was defective in such a way as to allow of the flame being blown upward (to the top of the gauze). On the other hand, experiments subsequently made with the very same lamp seem to point to the possibility that incomplete combustion of the fulminating-caps connected with the igniter leaves behind particles, the flame from which is quite capable of flashing through the double gauze of the lamp. It is noted that the excessive inflammability of these fulminating-caps is no new discovery, as similar results have been observed in the course of experiments carried out both in Great Britain and in Belgium.

L. L. B.

EXPLOSION AT THE DESDEMONA SALT-MINE, HANOVER.

Die Explosion auf dem Kaliwerk der Gewerkschaft Desdemona im Leinethal, Bergrevier Hannover. By — WIGAND. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussischen Staate*, 1906, *vol. liv., pages* 461-473, *with* 3 *figures in the text and* 1 *plate.*

The Desdemona mine lies midway between the Frisch Glück mine at Limmer (where a disastrous fire-damp explosion occurred in 1904) on the north-west, and the Hohenzollern mine on the south—all three belonging to the Leine valley group of potassium-salt mines. The presence of inflammable gases in such mines has long been known, but the extent of the danger was not, at first, realized; and the Frisch Glück explosion was regarded as a quite

exceptional occurrence. Moreover, the view was widely held that there was a necessary connexion between the presence of anhydrite, etc., and the evolution of dangerous gases, and that these were not to be feared in the salt-beds themselves.

The strata in the district are highly disturbed; but, so far as can be ascertained, the three above-mentioned mines work the same potassium-salt horizon in the Zechstein (Permian) of the Leine valley. An account is given of the tectonic structure of the district, as also details of twelve bore-holes. Sinking operations begun at the Desdemona mine in October, 1901, were completed in 1905, when the shaft reached its present depth of 2,302 feet below the surface. There are four main levels, at the respective depths of 1,394, 1,558, 2,115, and 2,263 feet; the two uppermost form the upper, and the two lowermost the lower, division of the mine. Both divisions intercommunicate only by means of the shaft, and from that point onward are ventilated by entirely separate air-currents. It is not yet stated how many distinct beds of potassium-salt have been opened up at these levels. On the whole, the salt-beds dip like the rest of the strata, south-westward, and strike from south-east to north-west; but there are extraordinary variations, due to the disturbed stratigraphical conditions. There would seem to have been a mighty overthrust of the salt-beds and the overlying Bunter sandstone and Muschelkalk on to the Middle Bunter sandstone.

A description is given of the ventilating arrangements in the mine, from which we gather, among other particulars, that the brattice-cloths, nailed to wooden-frames and wedged up to the roof with wooden laths, were covered with a coating of fireproof paint, consisting of an intimate mixture of magnesium chloride and clay, which was renewed every week, and fulfilled (as the event proved) its purpose. Above bank a Capell fan was installed, with a guaranteed capacity of passing through 84,745 cubic feet of air per minute. At the time of the disaster, it is calculated that 8,475 cubic feet of air per minute arrived at the working-face in the 2,263 feet level, or about 565 cubic feet per man. On account of the high temperatures prevalent in the mine, the duration of the shifts was limited to 6 hours; and, in compliance with a Government ordinance of April 30th, 1906, measurements of the temperature were carried out at regular intervals, as indeed they had been at an earlier date at this particular mine in anticipation of the ordinance. Safety-lamps, which could only be unlocked with a special key, were in use at all the working-places; but the workpeople, who hardly knew what fire-damp was, had scant experience of the manipulation of safety-lamps or understanding of the purposes which they are intended to fulfil. It was the custom to drill a hole several feet in advance of the working-face, so as to ease off possible sudden outbursts of gas, as it was always assumed (as above-mentioned) that the presence of dangerous gases was connected with the country-rock and more especially with the anhydrite. For blasting or shot-firing, combined charges of dynamite and blasting-nitrate were used, and ignited by means of an ordinary fuse.

Despite the precautions observed in connexion with shot-firing and the other matters cited in the foregoing paragraph, an explosion took place on May 7th, 1906, which resulted in the death of four persons; two others were rendered unconscious, but were brought out scatheless. Four shots had been fired towards the end of the afternoon shift, and after a timed pause of 10 minutes, according to the account of these survivors, they proceeded to the working-face in order to see what had been the effect of the shots, when they were thrown to the ground by a violent blast of air. Springing to their feet

again, they relighted their lamps, which had been extinguished, and hastened towards the shaft, pursued by the smell of burning brattice-cloth, while the atmosphere of the roadway was full of inflammable gases. At the western cross-cut their lamps went out again, and they sat down, their further progress being barred by wreckage of brattice: shortly afterwards they lost consciousness. The work of the rescue-party was greatly hindered by heat and smoke, and more especially by the fact that electric lamps were not available, while the safety-lamps that were in use were continually going out. Three of the four dead bodies that were found were severely scorched, and brattice-cloths were in part carbonized: these had evidently smouldered, but had burnt without flame, and when the carbonized portions were subjected for several minutes to the flame of a spirit-lamp it was found impossible to re-ignite them.

Close investigation of the working-face showed that a large fissure (in reality, three parallel fissures) must have been met with, whence arose the outburst of gas. The rescue-party could find no trace of any dangerous gases remaining in the atmosphere of the workings, nor were any observed the next day on the occasion of the official investigation. The possible causes of the explosion are discussed in minute detail, and the conclusion is reached that the inflammable gases caught fire at the lamp of one of the victims, but exactly in what way will never be known.

In the hard salt (hard rock salt?), as distinct from carnallite and ordinary rock-salt, are cavities, of generally conical form but varying dimensions, in which are often occluded gases smelling of petroleum. In an exceptionally-large cavity, which assumes rather the tubular form, measuring 15½ feet in length and averaging 3¼ feet in diameter, the smooth walls were sweating an oil that smelt like petroleum a few days after the cavity had been opened up. Similarly, oil sweats out into some drill-holes in the hard salt to such an extent that it has been possible to collect sample bottlefuls and submit the contents to analysis and distillation. The crude oil is shown to have the following volumetric composition: benzine, 14·5 per cent.; petroleum, 58·5; paraffin, 21; and tar, 6. As to the gases occluded in the hard salt, the inference is fairly obvious, that they are not pit-gases in the ordinary sense of the word, but merely the distillation-products of the above-described oil. Although no traces of oil have ever been found in the carnallite, it is beyond question that gases are occasionally occluded in that mineral. L. L. B.

EXPLOSIONS IN PRUSSIAN COLLIERIES DURING THE YEAR 1905.

Mittheilungen über einige der bemerkenswerthesten Explosionen beim preussischen Steinkohlenbergbau im Jahre 1905. [OFFICIAL.] *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussischen Staate*, 1906, *vol. liv., pages* 421-438, *with* 8 *figures in the text and* 3 *plates.*

At 10·30 a.m. on June 28th, 1905, a fire-damp explosion took place in No. 5 western division of No. 6 level, in the workings of the Emil seam at the Holland colliery, district of Wattenscheid. The seam is 4½ feet thick, lies 341 feet below the Laura or Main seam, belonging consequently to the Upper Bituminous coal-group, and gives off extremely little gas. The dip is variable, from 10 to 50 degrees northward, but decreases on the whole as the depth from the surface increases. A description is given of the conditions of ventilation in that part of the workings which was the scene of the disaster, and it is pointed out that neither the overmen nor the officials who inspected the place 2 hours or so before the occurrence, noticed the slightest trace of fire-damp in the atmosphere. Of the five persons at work there four

were killed on the spot, and the only survivor (an apprentice hewer) succumbed to his injuries a few days later. According to his death-bed account of the catastrophe, two sharp reports were followed by the extinction of his safety-lamp, and he observed no flame; he felt his lips, face, and hands suddenly swollen up, and crawled on his hands and knees to the cross-cut; he heard the hewer, whose duty it was to look after the Pelzer fan at that point, moaning, but had just the strength to throw himself into the water-tank and then lost consciousness. Others, who were at the cross-cut in the Bismarck seam, heard a rolling as of thunder, but saw no flame: their safety-lamps were suddenly extinguished, and they were hurled back a few paces. After rescuing the apprentice-hewer, and noting that the fan was still at work, although the air-conduits were in part destroyed, they had to beat a retreat, as the after-damp was meanwhile penetrating even into the workings of the Bismarck seam. In the course of 36 hours, the bodies of the dead, who were found to have suffered severe burns, were recovered; it was shown that death must have been almost instantaneous, and that the men fell where they stood. Two of the safety-lamps used by the victims were found much damaged; but they were both locked, and the igniters were in perfect order. The continued evolution of fire-damp prevented a thorough inspection of the scene of the disaster until July 19th, three weeks later. It was then seen that the timbering had sustained but little damage, but that some 130 feet of suction air-tubing had been rendered useless. There was no trace of coke-incrustations at any point, and the conclusion is reached that coal-dust played no part in the explosion. This seems to have been due to the sudden outburst of a gas-blower, which caught fire at the overman's safety-lamp (the wire-gauze of which, both inner and outer, was damaged). The shape of the holes in the gauze suggests that it had received an accidental blow from a pick.

In the Wattenscheid district again, an explosion took place at 8·30 p.m. on October 31st, 1905, at the Centrum colliery, in the deep-level workings (No. 6) in the Franziska seam. Four men were badly burnt, and two of them succumbed to their injuries within 48 hours. The Franziska seam has a thickness of $7\frac{1}{4}$ feet (inclusive of partings), and dips 47 degrees southward. Water-spraying appliances were in regular use, and the deputy who inspected the workings in that seam at 7·15 p.m., reported that no coal-dust was discernible anywhere. There had been some slight falls of stone, which occasionally interfered with the loading-out of the coal; consequently, in order to get rid of some of the bigger stones, two shots had been fired (although this had been distinctly forbidden) apparently with dynamite-cartridges, and the second shot started the explosion. A great flame burst out from the seam into the cross-cut, and afterwards beads and incrustations of coke were found on the timbering in the vicinity, although the floor was everywhere damp and in parts actually wet. The official view is that this was a coal-dust explosion pure and simple; fire-damp can hardly have played a part here, taking all the circumstances into consideration, and, in fact, no fire-damp was observed in the workings after the disaster. The shot-firer, with reprehensible carelessness, had ignited a dynamite-cartridge amid loose stone, and had neglected to render the coal-dust harmless by spraying it over with water before he fired the shot.

On November 17th, 1905, at 7 p.m., an explosion of fire-damp took place in the Henry pit of the De Wendel colliery, in the mining district of Hamm, whereby two hewers sustained more or less severe burns. The colliery is still in course of being opened up, and is provided with one haulage or winding-shaft and one ventilation-shaft. From the lowest of the two levels so far driven (2,395 feet), west of the northern main cross-cut, and about 700 feet

distant from the main shaft, a vertical staple was being driven, which had reached a height of 262 feet on the day of the accident: it was timbered, and divided into three segments for travelling, carriage of timber, and rolling down stone, etc. In the previous shift, the floor of the Anna coal-seam, 2½ feet thick, and dipping 9 degrees northward, had been laid bare; and a compressed-air system of conduits, providing the power for machine-drilling, and available also (if need were) for increasing the ventilation, had been erected in the staple. On account of the laying-bare of the Anna seam, instructions had been given to make an examination for fire-damp every ½ hour, and to bring the ventilating air-conduits closer up. In the course of scaffolding work, a man was holding a safety-lamp near the roof when fire-damp appeared in the gauze, and the man was so greatly scared as to drop the lamp; as it fell, the flame flashed through the double wire-gauze, and the fire-damp was exploded with a loud report. The official investigation showed subsequently that there had been no tampering with the lamp-locks; that coal-dust bore no share in the explosion; and that the volume of fire-damp involved was comparatively small, as the dynamic effects of the explosion were hardly noticeable, and only two out of the three men within reach sustained any injury. If the man who held up the safety-lamp had shown more foresight and presence of mind, the accident would probably not have happened at all.

About 11 p.m. on December 5th, 1905, a fire-damp explosion occurred *above* bank at the pit-head of the Werne colliery, also in the Hamm mining district, with the result that one person was severely injured and seven were slightly injured. This colliery had only been at work for a short time, yielding a daily output of about 1,000 tons and employing 1,600 workpeople. There are two shafts, each 19 feet in diameter, some 270 feet apart: one being used for winding, and the other for ventilation. The eastern district of the colliery worked twelve seams, all dipping very steeply, much disturbed, and extremely fiery; this district accounted for two-thirds of the entire output of the colliery. There is a causal connexion between the explosion and a pit-fire, which broke out on November 26th, 1905, in section 2 of the eastern district, and had assumed such an extension as to necessitate the stopping-off of the entire district. The origin of the fire was uncertain: the officials held, however, that it was, at all events, not due to spontaneous combustion, and took measures directed to its speedy extinction. Encouraged by the samples taken from a tube inserted in one of the masonry-dams (showing that no gases of combustion were remaining in the area of conflagration), and being anxious to replenish the sorely-diminished stock of bituminous coal, the officials caused a large opening to be made in the dam at 9 a.m. on the day of the explosion. Fire-damp issued in considerable volume, but was sufficiently diluted by the powerful ventilating-currents flowing in from north and south. The second dam, for safety's sake, was only to be opened up late in the evening, after the termination of the afternoon shift; this was done about 10·45 p.m., and then fire-damp streamed out in enormous quantities. Meanwhile, something went wrong with one of the motors that were driving the ventilators, and this had just been set right when the explosion took place above bank. A loud report was heard, and a sheet of flame shot out from the ventilator, while the floor of the engine-room rocked and the occupants were hurled about in all directions. The ventilators were smashed to fragments, their foundations were destroyed, though the two motors remained in place all but undamaged. The structures at the head of No. 1 shaft collapsed, windows in neighbouring buildings were shattered, and roofs and walls were damaged by flying parts of machinery. Below bank, the effects of the explosion were unimportant in

comparison, although some considerable damage was done. For many weeks thereafter haulage was entirely at a standstill, the remaining workable districts of the colliery yielding but little more coal than was sufficient for its own needs. An unprejudiced explanation of the cause of the explosion is not forthcoming: it can only be said, without fear of contradiction, that it started in the central engine-room, either in the ventilator itself or in its immediate neighbourhood.

Four men perished and four others were injured, as the result of an explosion which took place at 9 p.m., on December 7th, 1905, in the Eschweiler-Reserve colliery at Nothberg, in the mining district of Düren. Official enquiry has failed to elucidate the cause of the disaster, but it is supposed that a small blower of fire-damp (the presence of which had not been previously indicated anywhere in that part of the workings) was ignited at a naked light as the men were resuming work after an interval. Coal-dust evidently played a part in the disaster. A shot had been fired, probably with gelatine-dynamite; a foot or two away from the drill-hole a safety-lamp was subsequently found, with its glass cylinder smashed, and a little tin-box containing matches. No fire-damp was ascertainable as present after the catastrophe.

L. L. B.

EXPLOSION AT THE REDEN COLLIERY, NEAR SAARBRÜCKEN, GERMANY.

Die Explosion auf der königlichen Steinkohlengrube Reden bei Saarbrücken am 28. Januar 1907. By — Einer. *Zeitschrift für das Berg-, Hütten- und Salinenwesen im preussischen Staate*, 1907, *vol. lv., pages* 167-190, *with* 3 *figures in the text and* 1 *plate.*

On Monday, January 28th, 1907, shortly after 7 a.m., a disastrous fire-damp and coal-dust explosion took place in the Government colliery at Reden, wreaking greatest havoc in the remote Nos. 14 and 15 districts of the Thiele seam. No less than 149 persons were killed on the spot, one man died later in hospital from the results of carbon monoxide poisoning, and 37 persons suffered more or less injury from burns, from the dynamic effect of the explosion, or from breathing in after-damp. The Thiele seam is the third, counting from the top, in the bituminous coal-group, and is being actively worked; while the two uppermost seams (the Stolberg and the Carlowitz) have not as yet been touched in the Reden concession. This Thiele seam is about 6½ feet thick, dips 14 degrees north-north-westward, and has, apart from a few insignificant local disturbances, a very regular lie. It yields a coking coal of good quality, and contains 38·35 per cent. of volatile matter (calculated from ash-free material). But little shot-firing is needed in the course of getting the mineral; roof and floor alike consist of fairly compact and tough shales. The pressure or creep that ensues on working-out of the coal is considerable. The invariable method of working is longwall, and the average daily output of the two districts chiefly affected amounted to 420 tons.

The seam is not especially fiery: a sample of pit-gas, taken in January, 1907, not very long before the explosion, yielded barely ½ per cent. of methane. At no time in the colliery did the percentage of methane exceed 0·6 per cent., and the evolution of gas may be reckoned at 530 cubic feet per ton of output. It is true that in the course of forewinning operations, there was now and again an incursion of fairly large volumes of gas; but, in the weeks preceding the disaster, practically no fire-damp had been observed, either at the working-face or in the forewinning. Such gas as did penetrate into the workings is believed to have streamed in through fissures in the roof from the Carlowitz

seam (20 feet above the Thiele seam) which is known, and proportionately feared, throughout the Saare coal-field as extremely fiery. Be this as it may, no explosions had as yet taken place in the Reden bituminous coal-field. Daily examination of the workings for pit-gas was carried out, and the results thereof were reported above bank before the men went down. But eye-witnesses aver that, on the morning of the disaster, the two overmen, whose duty it was to conduct this examination in the particular districts involved, started work so late, that they could not possibly have complied with the strict letter of the regulations and have traversed every foot of the workings. However, the two overmen reported all workings in their respective districts as quite free from fire-damp before the commencement of the morning shift, and they both perished in the explosion. The barometer which, on Saturday, January 26th, stood at 29·33 inches (745 millimetres), rose about noon on Sunday, the 27th, to 29·53 inches (750 millimetres), at which height it remained up to the time of the disaster. Three hours later (10 a.m. on the 28th), it fell to 29·29 inches (744 millimetres), and a deep depression set in during the night of the 28th to the 29th, a minimum of 28·78 inches (731 millimetres) being registered on Wednesday, the 30th. The normal height of the barometer calculated at sea-level, is 28·86 inches (733 millimetres) for the altitude of Reden.

There is no question about the dustiness of the Thiele seam—and the dust which it makes is excessively fine. There is nowhere enough natural moisture in the pit to render this dust innocuous; and consequently, in accordance with the regulations, a water-spraying system is in constant activity, except on Sundays and holidays. Ventilation is effected by means of a Pelzer fan, 10½ feet in diameter, normally capable of passing through more than 77,680 cubic feet of air per minute; this amount, without any undue strain on the installation, can be raised to 106,000 cubic feet per minute, an increase which was actually found practicable immediately after the explosion. The fan is driven by a horizontal single-cylinder engine, of 80 effective horsepower. The water-gauge diagram, reproduced by the author, showing the extraordinarily sudden steepening of the curve, constitutes a striking record of the effect of the explosion. Details are given of the system of air-splitting, and it is stated that the temperature of the air-currents after passing through the mine averaged 78·8° Fahr. All the safety-lamps used at the working-face were benzine single-gauze; double-gauze lamps were occasionally used in forewinning operations. The lamps were lighted from inside (without unlocking) by means of a friction-igniter, which has always given satisfaction; the general upkeep and cleansing of the lamps was also satisfactory, and an examination of those used by the victims of the disaster revealed nothing that would point to wilful damage, forcible opening, etc. The explosives used for shot-firing were partly wetterdynamit and partly kohlenkarbonit. It had never been found necessary, either on the part of the colliery-officials or on that of the Government inspectors, to restrict the firing of shots in any way.

When the disaster occurred, the shift had hardly settled down to work; many of the miners had not reached their appointed places, and the pit-horses were just being hitched on to the tubs. About 7·15 a.m., a man reported that a violent rush of air from the main cross-cut had knocked him down, and it was evident that something unusual had happened in the workings, although no sign of it was observable above bank. All the officials went down the pit to the rescue, while messages were sent for doctors, ambulances, and parties with rescue-appliances. The after-damp, which is described as

rolling through the workings in the form of a greenish-grey mist, hampered considerably the efforts of the first-comers and drove them from one roadway to another. The survivors who were nearest to the scene of the explosion, claim to have heard two distinct reports, which became merged into one in the hearing of those farther away. A description is given of the condition in which some of the dead bodies were found, showing that several of the victims perished from asphyxiation by poisonous gases, but the great majority from burns and injuries sustained by falls of rock. The Dræger air-breathing apparatus seems to have been successfully used by the parties engaged in exploring the workings for possible survivors; as also the oxygen-cylinder, in the case of an overman who suddenly collapsed on his return from an inspection of his own district (to ascertain whether everyone had been safely withdrawn), and was brought back to consciousness in the course of 10 minutes by means of the insufflation of oxygen.

False alarms of fire occasioned a suspension of the rescue-operations, with a consequent delay of fully 24 hours. Operations were actively resumed on January 29th, and all the bodies of the victims, with the exception of four buried under an enormous fall of rock, were brought to bank the next day. Even these four bodies were recovered, after a week's strenuous exertion directed to the removal of the huge mass of fallen rock.

The author, in his capacity of Government district-inspector, examined the mine thoroughly, and gives a detailed account of his observations. He concludes that the disaster was in the main a coal-dust explosion, fire-damp playing only a secondary part therein. Coke-incrustations were observed in nearly every portion of the workings affected by the explosion. All endeavours to ascertain beyond question the actual cause of this catastrophe have remained fruitless; in a series of closely-reasoned paragraphs, the author dismisses one plausible supposition after another.

A few days after the occurrence, the Royal Mining Bureau at Saarbrücken issued an ordinance providing for the spraying of all dry coal-dust before the commencement of the morning shift, especially after Sundays and holidays; prescribing also a stricter system of selection of those who are to be entrusted with the supervision of both spraying and ventilation; and recommending an abstention from alcohol for 6 hours before entering on their duties, on the part of those officials and men who undertake the Sunday night-watch.

Other fresh precautions have been taken at the Reden colliery, including the use of double-gauze instead of single-gauze safety-lamps; and the Prussian Minister for Trade and Industry has nominated a commission to enquire generally into the conditions as regards safety of the Government collieries in the Saare coal-field, with power to suggest any changes that may seem desirable.

L. L. B.

FIRE IN THE BORUSSIA COLLIERY, DORTMUND, GERMANY.

Der Grubenbrand auf der Zeche Borussia bei Dortmund am 10. Juli 1905. [Official.] *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussischen Staate*, 1906, *vol. liv., pages* 642-670, *with* 11 *figures in the text and* 5 *plates.*

At the beginning of the morning-shift on July 10th, 1905, a haulier knocked over a hanging petroleum-lamp, which lighted the pit-eye at the fifth level in the winding-shaft of the Borussia colliery. Thereby a heap of timber was set alight; in a very short space of time the fire struck across the shaft, and the clouds of smoke that quickly filled the workings to the

north of it caused the death by suffocation of 39 miners out of the 81 who were at work therein. It was not until the beginning of May in the following year that all the bodies of the dead were recovered, as the fire had spread to a neighbouring seam, and its extinction was a necessary preliminary to the recovery of the bodies. The manager of the mine was prosecuted on the plea of manslaughter by negligence, and for having contravened two of the Government mining regulations, but was eventually acquitted on both counts.

No less than fifteen seams are worked in the Borussia colliery, and the daily output at the time of the disaster averaged 570 tons. The winding-shaft, 1,902 feet in depth, was of quadrangular cross-section built in masonry down to 115 feet, and thence downward lined with timber; it was entirely destroyed by the fire. The author notes, by the way, that this shaft had just been completed, when the Government ordinance of March 28th, 1902, came into force, prohibiting the timber-lining of shafts for the future. A special water-spraying arrangement kept up a sufficient dampness in the shaft, to comply with the mining regulations, which decree this where naked lights are used. As in all timber-lined shafts, continual repairs were found necessary; and the visits of Government inspectors were frequent. Three such visits of inspection had already taken place in 1905, the last before the disaster being on May 28th; apart from these special inspections of the shaft, there had been no less than twenty-two general inspections of the mine during the first six and a half months of that year.

The general testimony of the witnesses examined at the enquiry concurs in regard to the continually damp condition of the pit-eye at No. 5 level, and to the consequent absence of coal-dust there. The base of the hanging-lamp which started the conflagration, cannot have been more than 5 feet 10 or 11 inches above the floor: it was enclosed in a sort of quadrangular metallic lantern, the glazed openings in which had been shattered about a month before the disaster. Below it, on the morning of July 10th, 1905, were stacked about 100 pieces of pit-timber, which had been lying there since the night of the 7th to the 8th, and were to be distributed among the workings in the course of the morning-shift. The hauliers who were working at the pit-eye, in order to allow free play for the tubs, found it necessary to toss over to the rear part of the stack some of the props, and one of these knocked over the lamp: the petroleum flowing out of the lamp-reservoir immediately set the stack aflame. The hauliers made some efforts to extinguish the fire, to which curiously enough, they attached no great importance, in the intervals of their work. Presently, the former deputy-manager appeared on the scene, and reproaching the men for their negligence, caused more active measures to be taken. But these proved futile for various reasons, the chief being that the fire had already gained too great a hold. Then, through the mistake of a newly-appointed overman, the wrong brattice-doors were opened, with the result of driving the smoke and gases of combustion through a portion of the workings, and of causing erroneous conclusions to be formed above bank as to the course that the ventilation was taking.

A description is given of the various unsuccessful attempts to rescue the men who were unable to flee in time, and also of the final recovery in the night of May 1st to May 2nd, 1906, of the twenty-five remaining bodies.

In the course of the judicial proceedings above-mentioned, it was shown that water-hydrants and hose were duly available in the immediate neighbourhood of the scene of the fire; but, owing in some respect to flurry and forgetfulness on the part of the pitmen who should have used those appliances, they were not timeously turned to account, as they might have been.

As a consequence of the disaster, the Royal Mining Bureau of Dortmund issued an ordinance, which came into force on May 1st, 1906, forbidding the use of naked lights in places which are built otherwise than of masonry or constructional steel, and wherein combustible material of any kind is stacked even temporarily. Where such lights are permitted, they must be enclosed within glass which is shielded from any possible breakage, and must not be fed with petroleum, or spirit, or any similar easily-vaporized fluid. The use of portable electric lamps burning *in vacuo* is permissible in downcast shafts, at the pit-eyes communicating with them, and in the immediately neighbouring engine-rooms. Apart from the places specified in the ordinance safety-lamps alone are permissible. L. L. B.

CHOKE-DAMP DISASTER IN AN UPPER SILESIAN COLLIERY.

Tödliche Verunglückung dreier Personen in matten Wettern im Ostfelde des königlichen Steinkohlenbergwerks "König" bei Königshütte O.-S. By — STEINHOFF. *Zeitschrift für das Berg-, Hutten- und Salinen-wesen im preussischen Staate*, 1906, *vol. liv., Abhandlungen, pages* 298-299 *and* 1 *plate.*

This accident occurred on November 12th, 1905, in the eastern district of the State colliery of König, at Königshütte, and resulted in the death of three persons. For more than two years a portion of the workings in the Gerhard seam (18 feet thick) had been shut off by strong masonry-dams on account of pit-fires, and an endeavour was now made to ventilate that area. Chemical analysis of samples of the atmosphere taken from behind the stoppings showed it to contain, in volumetric percentages, 0·0023 of carbon monoxide and 4·874 of carbon dioxide. On the termination of the night-shift of Saturday, November 11th, provision was made for opening up successively two stoppings and drawing the gases out by means of the ventilator at the Bittkow shaft. At first all went well, but the overman to whom the arrangements were entrusted noticed that the ventilating current travelled very slowly into the old area of conflagration, and inferred that there was some obstacle, such as a brattice, to its passage. He thereupon ordered the two men who were working with him to search in the direction of the goaf, one of them being provided with a Giersberg apparatus and the other with a Shamrock Pneumatophore of the old type. It may be mentioned that both appliances had been overhauled shortly before and declared to be in proper condition, and that the men were thoroughly familiar with their manipulation. A third man stood ready with a reserve Pneumatophore, so as to be able to render immediate assistance if required. The two first-mentioned men went about 300 feet within the second stopping, when one suddenly grasped the other's arm, and, evidently feeling unwell, signed to him to turn back. As they did so, he stumbled on the partly broken-up floor and fell about 60 feet distant from the second stopping, with the probable result that the mouthpiece of the Pneumatophore slipped from his face. He had fallen among a lot of scattered timber, and being unable to rise immediately, shouted for help, whereby he breathed the deadly gases in full measure. His companion, who had heard the cry and seen him fall, rushed up to the stopping to get help to carry him out, as he felt too excited and too exhausted to do so unaided. The overman outside, without pausing to put on a Pneumatophore, ran behind the stopping, but had hardly gone 10 feet when he was struck down by the poisonous gases. Then a fourth man, under similar circumstances, sprang forward to the assistance of the victims, only to collapse in turn. Four other pitmen successively braved the dangerous atmosphere, col-

lapsing one after another, but were brought out by the first man who had run for help, as he had meanwhile somewhat recovered his strength. He made a heroic attempt to save the other victims, but found this physically impossible. Rescue-parties called up by telephone brought two men out (one of whom was the overman), but all endeavours at resuscitation unfortunately failed, and the body of the man who first stumbled and fell was not got out until later.

The breathing-appliances used by the two men who first went into the gas-laden area were subsequently condemned as untrustworthy; but it was held that the disaster would never have occurred, if the overman entrusted with the arrangements had carried them out in strict accordance with his instructions, and had not concerned himself with the inevitable slowness of the process of ventilation. Large volumes of a heavy gas such as carbon dioxide are always slow to move.

BOILER-ACCIDENTS IN FRANCE DURING 1905.

Bulletin des Accidents d'Appareils à Vapeur survenus pendant l'Année 1905. [OFFICIAL.] *Annales des Mines*, 1906, *series* 10, *vol. x.*, *pages* 586-598.

Among the 29 accidents recorded in France during the above-mentioned year, whereby 14 persons lost their lives and 33 others were seriously injured, none is stated to have occurred in or about a mine. One accident, which happened at a foundry at Tarnos, in the Landes, on July 28th, to a cylindrical boiler, resulted in slight injury to three workmen and considerable damage to property. The cause was evidently superheating, probably, but not certainly, occasioned by insufficient water-feed. Two accidents occurred at electric-power stations; one to a De Naeyer water-tube boiler, possibly due to the inadequacy of the precautions taken against incrustation; the other to a Niclausse water-tube boiler, due to superheating apparently occasioned by insufficient water-feed.

Eleven of the accidents are assignable to original defects in the structure or setting-up of the boiler, eight to defective upkeep, thirteen to faulty usage, and five to undefined causes. Thus thirty-seven causes are found for twenty-nine accidents, because in no less than five instances the accident was due to two several causes, and in one instance to as many as four. Non-tubular boilers were concerned in four cases, fire-tube boilers in eleven cases (which involved most of the recorded injury to life and limb), and water-tube boilers in six cases. L. L. B.

ACCIDENTS IN CONNECTION WITH ELECTRICAL INSTALLATIONS IN PRUSSIAN MINES DURING 1905.

Unfälle in elektrischen Betrieben der Bergwerke Preussens im Jahre 1905. [OFFICIAL.] *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussischen Staate*, 1906, *vol. liv.*, *pages* 439-448, *with 3 figures in the text.*

At the Rheinpreussen colliery in the Düren district, a man was instantaneously killed on January 13th, 1905, through meddling with a switchboard, from the hinder or rear part of which he had torn away the protecting cover, in the apparent endeavour to determine the cause of a momentary stoppage in the working of a high-tension triphase motor. It is evident that, in doing this, he must have touched a naked live wire.

At the Dechen colliery, in the mining district of Neunkirchen, an electric circular saw is worked by a current, transformed down to 220 volts from the tension of 5,000 volts at which it starts from the power-station at the neigh-

bouring Heinitz colliery. The wires are carried from the transformer-room past the coal-washery at the Dechen colliery. At the very summit of the stairway of this coal-washery is a window for admitting the air, and from this window the wires are at least 2 feet distant; and therefore no one leaning out of the window could come into merely accidental contact with them. It would seem that on February 2nd, 1905, a haulier ran up to this window, opened it, and leaning forward snatched at the wires. He was standing on an iron stair, was shod with iron-nailed and damp boots, and thus made a short circuit between the wire and earth. All efforts to bring him back to life proved futile. Since that occurrence the window has been screwed up.

A fatal accident which happened on August 15th, 1905, at the Ver. Constantin-der-Grosse pit, in the Nord-Bochum district, shows that in damp mines continuous currents at a tension of only 220 volts are dangerous. An apprentice-hewer, officiously pushing forward to help in the uncoupling of a truck from an electric locomotive in the roadway of No. 1 level, attempted to squeeze past the locomotive, bending forward with his hands upon it, and touched a contact-button with his face, thus completing the circuit. His body was damp with sweat, and the floor on which he was standing was drenched with moisture. It is thought that, under other circumstances, the tension would have hardly been sufficient to kill the unfortunate youth.

At the Deutscher Kaiser colliery, in the Duisburg district, on Christmas Eve, 1905, a man was killed by accidentally grasping the wires through which a current passes, at a tension of 550 volts, for working a coke-oven discharging-machine. He was watching the preparatory operation of raising the oven-doors from a staging close to the machine, when, probably in craning forward to look at the farther side of the oven, he lost his balance, and involuntarily grasped the wires through one of the openings in the screen erected to protect the wires from accidental contacts. The current having been switched off, he fell to the ground, but all attempts at resuscitation proved unavailing.

Two men employed at the electrical installation of a colliery at Linden in the Hattingen district, were killed on July 27th, 1905, in the dinner-hour, by touching the naked clips of a cable which linked up the colliery-installation with the central high-tension station at Essen. As it was proposed to lay another (but temporary) cable to link up with Essen, it is assumed that they were engaged in ascertaining the most suitable way of laying it under the circumstances, but unaccountably forgot that the Essen line was never switched off, although the motors at the colliery itself were switched off.

At the Neuhof zinc-mine in the Tarnowitz district, a locksmith, who was helping a man to carry a naked wire along the roof of a building in the immediate vicinity of an insulated high-tension system, was holding the free end of the wire ready for attachment to a porcelain insulator when he came into contact with the high-tension cable, and was mortally injured. Evidently, the insulation of the high-tension cable, which had been subjected for two years to all the stress of weather, was defective; moreover, the roof, covered with bituminized sheeting, was wet from recent showers, and thus played the part of a conductor. Contrary to regulations, the man was unprovided with indiarubber gloves, and he should have had an indiarubber mat to stand on. Adequate inspection and measurement of the insulation (although the latter is not expressly prescribed) would have revealed its defective condition.

At the Kaiserstuhl I. colliery, in the Dortmund II. mining district, a man who was about to do something to an amperometer, forgot to take out certain safety-fuses from the distributing-board, by which he would have cut off from a switch-lever the current passing at a tension of 2,000 volts to the

motor: He grasped the lever with his bare hand, and was instantaneously killed by the entire current passing through his body.

A man had started to let down an arc-lamp, one of two that were not burning properly and were therefore being examined, at the Siegmundshall potassium-salt mine, Wunstorf, district of Hanover, on November 16th, 1905; but he had barely touched the lowering cable when he fell lifeless to the ground. A high-tension system (alternating current, 500 volts) for power-purposes is carried along parallel with the arc-lamp wires at a distance of 2½ feet below them. It was afterwards ascertained that the lamp-wires, heavily laden with hoar frost and snow, had so bent under the weight as to come into contact with the high-tension wires; and the insulation of the former wires was not sufficient to prevent the diversion of the current from the latter to the lamp and the lowering cable connected with it.

The foregoing are fairly typical examples, but an account is given of thirteen other accidents, only one of which, however, resulted fatally. Some of them appear to have been due to sheer carelessness or forgetfulness, others to neglect of necessary precautions; but few seem to have been really unavoidable. L. L. B.

ACCIDENTS IN CONNECTION WITH ELECTRIC APPLIANCES AT PRUSSIAN MINES DURING THE YEAR 1906.

Unfälle in elektrischen Betrieben auf den Bergwerken Preussens im Jahre 1906. [OFFICIAL.] *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussichen Staate, 1907, vol. lv., pages* 311-323, *with* 2 *figures in the text and* 1 *plate.*

Of the twenty-nine accidents described in this paper, the following are among the most serious:—

A mason, who had some work to do in the coal-picking department of the Gräfin Laura colliery at Chorzow, in the Königshütte mining district, carelessly touched, despite the most explicit warnings, some wires (conveying current at 500 volts) which had been laid bare in order to make fresh connections to them, and he was discovered hanging to the wires, a lifeless corpse.

On March 24th, 1906, a fatal accident occurred in connection with a new electric power-plant, at the coke-ovens attached to the Deutscher Kaiser colliery, in the Duisburg mines-inspection district. On attempting to switch on a high-tension current after the dinner-hour, the man in charge, momentarily startled by the explosive violence with which an arc-like spark made its appearance, involuntarily made contact with his bare right hand, and was struck dead instantly. "Super-tension phenomena," producing sparks with explosive violence, are likely enough to occur when several motors are switched on again, after a pause such as that of the dinner-hour. In this case, a few days after the fatality, super-tension was repeatedly observed, until a defect in a cable had been set right.

In the course of tarring a roof at the Cons. Trautscholdsegen colliery, in the South Kattowitz Mines-inspection district, on May 11th, 1906, a workman touched a naked wire conveying current at 500 volts; it is supposed that he slipped, and involuntarily caught at the wire in order to recover his balance.

At the Germania I colliery, in the third Dortmund mines-inspection district, a youth who, after eight days' apprenticeship, was engaged in polishing up a 1,800-kilowatt generator which was at rest, clambered, for reasons best known to himself, down into the flywheel pit, and, in attempting to get out again, touched a spot in one of the continuous-current cables where the insulation was afterwards shown to be defective, and so met his death.

At the Royal Maybach colliery, in the Eastern Saarbrücken mines-inspection district; at the Kostuchna colliery, in the South Kattowitz mines-inspection district; at the Wansleben salt-mine, in the Western Halle district; at the Shamrock I/II colliery, in the Herne district; and at the Radzionkau colliery, in the Tarnowitz district, fatalities occurred which were in every case due to carelessness and wilful disregard of the regulations on the part of the victims. To the same cause must be assigned at least ten of the non-fatal accidents described. Defective insulation would account for three other non-fatal accidents; as also for the fatality which overtook a man who was cleaning a boiler at the Ver. Hagenbeck colliery, in the South Essen district. He was using a portable electric lamp, supplied from the central station of the colliery by means of an alternating current at 110 volts; the fatal effect of the electric current was enhanced by the circumstance that the victim, who was very corpulent, was sweating a good deal and sitting on an iron boiler-tube. The fatality shows the necessity of perfect insulation of the handles of such lamps, as also that all external metallic parts (such as the protective gauze) should be set on that insulated handle or grip.

L. L. B.

UNDERGROUND TEMPERATURES: VALUES OF THE GEOTHERMIC DEGREE.

Normale und anormale Werthe der geothermischen Tiefenstufe. *By* JOH. KÖNIGSBERGER. *Centralblatt für Mineralogie, Geologie und Paläontologie*, 1907, *pages* 673-679.

One of the objections advanced against the hypothesis of regular increase of temperature, concurrently with increased depths from the earth's surface, is based on the extreme irregularities observed in underground temperatures near the surface. Such irregularities are undeniable: at some localities (*e.g.*, Neuffen) there is a rise of 1 degree Fahrenheit for every 18 feet of depth, at others (*e.g.*, Chicago) the rise is 1 degree for every 128 feet of depth; and there are metalliferous mines where even a fall of temperature is locally noted with increasing depth. But these different values are not irregularly distributed, as some writers have thought; they can be grouped in well-defined categories dependent on geographical and geological factors, and this grouping is defensible by arguments drawn from physics and mathematics.

The author gives a series of tables embodying the known geothermic values in different localities classified as follows:—(1) localities in practically flat country, the rocks being chemically unalterable by atmospheric agencies, and not belonging to the series of younger eruptives; (2) localities in practically flat country, the rocks being chemically unalterable, but lying in the vicinity of great areas covered by water; (3) observations under mountains and valleys; (4) localities where the rocks belong to the younger eruptive series; (5) localities where the surface is dry sand or some other substance which is a bad conductor of heat; (6) localities neighbouring heat-producing deposits: including (*a*) the productive Coal-measures, collieries, oil-wells, etc., and (*b*) metalliferous mines; and (7) measurements taken in mines where the entire mass of rock is cooled by artificial ventilation.

The mean value of the geothermic degree obtained from the most satisfactory measurements in Table I. differs but little from the mean value obtained from all the measurements, and amounts to 58 or 62 feet per degree Fahrenheit: it depends somewhat on the thermal conductivity of the

rocks concerned. This factor, as also the varying evolution of heat according to the lie of particular deposits and the apparently extreme irregularity of the surface at which different temperatures prevail, constitutes an obstacle to the strictly mathematical solution of the problem under consideration. Approximate calculation, however, shows that in practice the variation in thermal conductivity k may be neglected, provided that it does not exceed the double or treble of the original value. Yet the absolute values of k, as determined for the same rock (in the dry state) by different observers, vary by more than tenfold. Provisional experiments on rocks in the naturally moist condition, conducted according to Mr. W. Voigt's method, show that the variations from rock to rock or those dependent on the conditions of bedding are far less important than is ordinarily assumed.

Concerning Table IV., it is remarkable how enduring in time and extended in space is the influence of eruptive magmas. It will be noted that there are regions where magmas, still in the molten condition, occur at comparatively shallow depths, and the investigations of several geologists have shown the extreme probability that volcanic eruptions herald their approach long beforehand by thermal phenomena. The author has thought out a simple alarm-signal, which, placed in a borehole some 100 feet deep or so, at the base of an active volcanic cone, and registering slight elevations in temperature, might give indications of an outburst many months before it actually occurs.

He considers that careful observation of volcanoes along these lines would be of far greater practical value than, and of quite as great theoretical interest as, the detailed and very costly investigation of seismic phenomena which is now everywhere the fashion. L. L. B.

THE DISTRIBUTION OF METALLIFEROUS ORES IN DEPTH.

Die Einteilung der Erze, mit besonderer Berücksichtigung der Leiterze sekundärer und primärer Teufen. *By* P. Krusch. *Zeitschrift für praktische Geologie*, 1907, *vol. xv., pages* 129-139.

The author, in a paper read to the German Geological Society, had already endeavoured to prove that certain ores are characteristic of what he terms "secondary" and "primary" depths respectively, and therefore may be regarded as good indicators for those depths. He then cited a few examples in support of his contention, but he now enters into a complete and detailed investigation of the subject.

If the mere quantity of ore be taken into account, the unaltered primary varieties may be well said to predominate, their uppermost limit being generally the underground water-level of the country, and the distribution of metal in them appearing to conform to certain definite rules. Above the underground water-level, a displacement of the original metallic content is manifest, and a just appreciation of the extent of that phenomenon furnishes a key to the right understanding of the particular ore-deposit with which one may happen to be concerned.

Stress is laid on the fact that every deposit to which the surface-waters have access is subject to alteration. The phenomena of decomposition are dependent on the nature of the ores, not on their genesis. Primary ores of similar character exhibit similar decomposition-changes under similar conditions, whatever their origin may have been. The "oxidation-zone" of ore-deposits is characterized by the oxides, carbonates, sulphates, chlorides, and more rarely the bromides and iodides of the heavy metals; while the

"cementation-zone," at greater depths, where all the oxygen carried by the surface-waters has been used up, exhibits the enrichment due to the precipitation from undecomposed metallic sulphides, etc. If the processes of solution and reprecipitation extend over a very long interval of time, certain quantities of metal may accumulate just above the underground water-level, having been perhaps originally dispersed over hundreds of yards (in depth) of primary ore-deposit; and a characteristic feature of the cementation- or concentration-zone is the appearance of native metals in large quantity, or at all events, of richly metalliferous sulphides and arsenides.

The investigation of an ore-deposit and a true estimate of its value must be based on the differentiation of ores into (1) oxidic ores; (2) cementation-ores; and (3) primary ores. But the ores of some metals have proved refractory to the displacement of their original metallic constituents, and consequently another classification, in a different order of ideas, also holds good: (1) ores with well developed oxidation- and cementation-zones; and (2) ores which, owing to their refractoriness, have suffered no variation in their original metallic constitution.

If the chemical action of erosion is, in certain localities, slower than the physical, the primary ore-deposit may there be seen to crop out at the surface; if the chemical action is the quicker of the two, then both the oxidation- and the cementation-zones may be observed, or the last-named alone, in which case it also crops out at the surface. Where the infilling of the lode is tougher than the country-rock, it forms a dyke or wall, enabling the most inexperienced prospector to "spot" the ore-occurrence and therewith the rich cementation-zone. On the borders of the newer mountain-belts where erosion has attained its maximum intensity, and in regions where glacial action has been a predominant factor, the usual decomposition-zones of ore-deposits have been swept out of existence, and therefore one must not always expect to find decomposition-zones, even in the case of ores which are prone to decomposition.

Starting from these premises, the author first of all considers the various occurrences of gold, pointing out that perhaps auriferous pyrites, in which gold is only an accessory constituent, is the most important ore of that metal. He animadverts on the serious mistake, to which many prospectors and engineers have laid themselves open within recent decades, of regarding the gold of the cementation-zone as primary, and assuming its continuance in depth. Where atmospheric agencies work faster than the processes of cementation, and the rich cementation-zone crops out like a reef at the surface, the beginner or the "man in the street" is very apt to regard an auriferous deposit which really becomes barren at a shallow depth, as an extraordinarily rich occurrence.

With regard to cupriferous ores, their cementation-zone is characterized by the occurrence in large quantities of copper-glance, chalcopyrite, erubescite, and native copper. The accumulation of these minerals is an infallible indicator of the cementation-zone of cupriferous deposits. Extreme caution on the part of the prospector is, in such cases, advisable, and the question as to the depth, according to the character and "habit" of the deposit, to which the ores may extend, should be weighed with the greatest care.

Coming then to iron-ores, the author notes that a deposit which primarily (in depth) may consist of magnetite, hæmatite, and limonite, may have very nearly the same composition at the surface; but with spathic ore it is otherwise, and a brown hæmatite at or near the outcrop may well be merely the oxidation-zone of a spathic ore-deposit. In the

latter case, a superficial investigation often leads to exaggerated estimates of the value of the entire deposit.

Classifying manganese-ores in two groups: (1) the oxidic and hydrated ores; and (2) the carbonates and silicates, the former group being richest in manganese, the author points out that the oxides and hydrates are very refractory to the decomposing action of surface-waters. On the other hand, the silicates and carbonates in the neighbourhood of the surface pass into oxides and hydrates (which in such cases are characterized by their porosity and generally cavernous structure). Wherever, therefore, workings in such ores have not penetrated below the underground water-level, the possibility exists of finding the primary ores, rhodonite and rhodocroisite, at greater depths.

Both nickel- and cobalt-ores are divisible into three clearly-defined groups: (1) the arseno-sulphidic ores, occurring in lodes similar to the sulphidic lead-silver-zinc lodes; (2) the oxidic ores, occurring chiefly in veins coursing through decomposed serpentine; and (3) the nickeliferous and cobaltiferous magnetic pyrites, which are original magmatic segregations from basic eruptives.

In the case of a complete section of a silver-ore deposit, the oxidation-zone is, on the whole, poor in the precious metal, the chloride being perhaps the most frequent silver-bearing constituent therein, with now and then a little native silver, and still more rarely the bromide and iodide of the metal. The cementation-zone is characterized by the occurrence of considerable quantities of native silver, silver-glance, antimonides and arsenides of silver, stephanite, silver fahlore, and red silver-ores (the last-named, especially, are practically confined exclusively to the cementation-zone). As at great depths in that zone, the original sulphides are often to a large extent present in their unaltered condition, it may be as well to point out how the primary galena, say, is distinguishable from the galena of the cementation-zone: in the former, silver is dispersed throughout in an extremely fine state of division, in such wise that an assay of as much as 16 ounces per ton is quite exceptional; in the latter, native silver is seen coating every crack and cranny, every pore and crevice, and assays of 320 ounces per ton, and even more, are not unknown. The same remark holds good of the argentiferous zinc-blendes.

With regard to the mercury-ores, it is important to note that the occurrence of cinnabar in the oxidation-zone does not always imply that the same ore occurs at greater depths; it may there, and more probably, be represented by mercury fahlores. In dealing with occurrences of native mercury, extreme caution is advisable in speculating as to which particular ore the metal has been derived from.

To those metals of which no oxidation- and cementation-ores (as defined by the author) are known, belong molybdenum, tin (in the form of cassiterite), iron (in the form of red and brown hæmatite), manganese (in the form of oxides and hydrates), wolfram, chromium, platinum, thorium, and aluminium. L. L. B.

ORIGIN OF PYROPISSITE OR "PARAFFIN-COAL."

Ueber die Entstehung des Pyropissits. *By* Max Heinhold. *Jahrbuch der Königlich Preussischen Geologischen Landesanstalt und Bergakademie zu Berlin*, 1906, *vol. xxvii., pages* 114-158, *with* 3 *figures in the text.*

The mining district of Zeitz-Weissenfels in the Prussian province of Saxony is the only area so far known where pyropissite has occurred in sufficient quantity to justify the existence of a flourishing paraffin-industry

based on the extraction of paraffin from it. The brown-coal formation there consists of a series of clays, loams, sands, gravels, and tough quartzitic sandstones alternating in indeterminate succession. The brown-coal itself, however, forms a recognised geological horizon; it is an earthy dark-brown to black mineral, and yields an excellent fuel. With it is associated a black sandy dust, known to the hewers as *kokskohle* (coke-coal), of no economic value. When the brown coal becomes very rich in constituents susceptible of distillation, it passes into pyropissite, those parts of the seam being lighter in colour than the rest. This "paraffin-coal" in the fresh condition is a more or less plastic brownish mineral, greasy to the touch; on drying, according to its less or greater purity, it turns yellow or whitish, and crumbles away between the fingers. It has a dull, earthy, uneven fracture; but a fractured surface, if scratched with the finger-nail, becomes shiny. It ignites easily at a candle-flame, and gives off an aromatic tarry smoke. The author ascertained its average specific gravity to be 1·12. He supplies a bibliographical list of thirty entries, ranging chronologically from 1799 to 1905, and devotes the second chapter of his memoir to a synopsis of the views advanced and facts recorded in these publications, accompanied by a running commentary. In the third chapter he deals with the chemistry of the subject. On treatment successively with ether, benzol, and alcohol, the following percentage results were obtained with two samples of pyropissite from Gerstewitz:—

	No. 1.	No. 2.	Recent pyropissite from East Africa.
Soluble in ether	6·55	4·81	80·24
Soluble in benzol	36·45	31·09	3·86
Soluble in alcohol	2·11	8·43	6·24
Insoluble residue	54·89	55·67	9·66
	100·00	100·00	100·00

Further investigation with the same samples from Gerstewitz yielded the following percentage results:—

	No 1.	No. 2.
Hygroscopic water	4·84	5·26
Ash	7·84	14·88
Organic matter	87·32	79·86
	100·00	100·00

The extracts dissolved out by ether and benzol, and more especially those dissolved out by alcohol, contained abundance of free acids, which were easily saponified at the normal temperature by ordinary alkali (potassium-ley). This chemical investigation leads inevitably to the conclusion that the decomposition of the organic fatty or wax-like substances, from which pyropissite is derived, had been interrupted before it had reached a very advanced stage. A full list is given of the flora of the Weissenfels brown-coal formation, and it is observed that the resinous constituents of the pyropissite are undoubtedly, in part at least, derived from the conifers which are so abundantly represented in that flora. The remains of leaves, etc., in that formation, show that dicotyledonous plants were numerous; but the wood of the deciduous trees, extremely variable in its capacity of resistance to the phenomena of decomposition, is incomparably more quickly decomposed than coniferous wood, and so but little dicotyledonous wood is preserved in the form of brown-coal. The still determinable portions of plants

found in pyropissite by microscopic investigation include spores of fungi, etc., grains of pollen, epidermal fragments of dicotyledonous leaves, and fragments of coniferous cellular tissue having its meshes partly infilled with resin, partly empty, etc.

The Zeitz-Weissenfels district occupies a slightly undulating tableland, ranging in altitude from 660 to 1,000 feet above sea-level; and the Lower Oligocene brown-coal formation extends from the Rippach valley on the north to where the Elster cuts its way deep through the Bunter Sandstone on the south. It is split up by several valleys of erosion into separate patches, in each of which only one coal-seam appears to have been proved, and that not universally. Where neither the brown-coal formation nor the Bunter Sandstone have been laid bare by erosion, the whole country is mantled by drift-deposits. The entire thickness of the brown-coal formation ranges from 100 to 200 feet, and it rests conformably upon the Bunter Sandstone, its basement-bed being a bluish, greyish, or yellowish plastic clay of variable thickness. The main brown coal-seam is from 13 to 70 feet thick; and, in places, separated from it by a clayey parting, occurs another seam 3½ feet thick, yielding coal of inferior quality. Taken as a whole, the main seam is horizontally bedded, forming a series of very flat regular synclines. The occurrence of pure pyropissite therein is restricted to a few localities; and now, apart from some insignificant remnants at Aue, no unworked pyropissite remains, except under the village of Gerstewitz, where it is practically inaccessible. The pure mineral is said to have been found only in the lowermost portion of the main coal-seam, and generally at points where the seam is diminishing in thickness. It has been asserted that with the pyropissite was invariably associated the *kokskohle* or *schlackenkohle* ("clinker-coal") already mentioned, but not sufficient evidence is forthcoming nowadays to enable the author to test the full bearing of this assertion.

The pale-yellow beds of resinous vegetable wax (recent pyropissite) found along the banks of the Tana in the British East African protectorate, are probably drifted material derived from desert-plants that shed a variety of resinous wax; and in South Africa the widespread occurrence has been recorded of the geraniaceous plant *Sarcocaulon Burmanni*, the stems of which are covered with a crust of such wax, the function of which appears to be to prevent the dessication of the plant by protecting it against excessive evaporation. The natives, indeed, pick up the fallen stems, and use them as torches, whence they are known as "bushmen's candles." These recent examples throw light on the origin of the fossil pyropissite or paraffin-coal, which occurs in an area that in Tertiary times was probably covered with marshes and swamps, amid and around which flourished a luxuriant sub-tropical vegetation. A detailed account is given of the probable physical conditions, and consequently locally varying phenomena of decomposition, whereby from the same mass of vegetable material at one time or spot or horizon, brown-coal was formed, at another pyropissite, and at yet another clinker-coal. L. L. B.

CHEMICAL THEORY OF THE ORIGIN OF PETROLEUM.

La Genèse des Pétroles. *By* L. Pervinquière. *Revue Scientifique, series* 5, 1908, *vol. ix., pages* 389-393.

Apropos of the recently published monograph of Dr. L. C. Tassart on the working, etc., of petroliferous deposits, the author reminds us that petroleum is not a substance of constant composition with definitely fixed properties: consequently, one ought rather to speak of natural oils, in the

plural. These natural hydrocarbons belong to three different categories, typified by the petroleum of Pennsylvania, the Caucasus, and Galicia respectively. The American oil chiefly consists of compounds corresponding to the formula C_nH_{2n+2}; that of Baku, of compounds belonging to the C_nH_{2n} series; while that of Galicia includes hydrocarbons of both series, together with aromatic compounds derived from benzene corresponding to the general formula C_nH_{2n-6}. This difference in composition, may, in part, account for the divergent theories put forward as to the genesis of petroleum: while all American writers, and not a few Europeans, uphold the organic origin of that substance, the Russians just as stoutly uphold its chemical origin. Several of those authors who consider that petroleum may quite well be the product of the distillation (owing to metamorphism) of plant-remains, have had the ground cut from under their feet by the recent observation of Mr. P. Sabatier, that the tars formed in the course of distillation of plant-remains or coal are made up of aromatic compounds with a large percentage of phenols and phenol-ethers, invariably absent in petroleum. Mr. Morrey considers that the Pennsylvanian petroleum was really formed from organic slimes by the agency of bacteria, and the experiments carried out by Dr. Engler would seem to lend considerable support to that view. On the other hand, those three illustrious chemists, recently deceased—Marcelin Berthelot, Moissan, and Mendeleieff, assigned an inorganic origin to petroleum; and the first two made the oil synthetically in the laboratory, though in neither case did they produce a petroleum of the same composition as that from Baku. Recently, however, Messrs. Sabatier and Senderens, using nickel as a catalysing agent, with a mixture of acetylene and hydrogen at a temperature of 392 degrees Fahr. obtained, after a lapse of 28 hours, a yellow fluorescent liquid possessing the characteristic odour and density of Pennsylvanian petroleum, and the same chemical composition. Using cobalt or iron under similar conditions, they obtained a brown or reddish oil, having the disagreeable odour that characterizes Canadian petroleum. By passing acetylene alone over nickel catalytically reduced from the oxide, heated to 400° or 600° Fahr., the metal incandesced, yielding thick fumes which condensed into a red green-shot liquid; now, if the vapours of this liquid be carried with an excess of hydrogen over fresh nickel heated to 392° Fahr., a transparent liquid is obtained, possessing the same physical characteristics as the Baku petroleum, and the same chemical composition. On repeating the first experiment with a mixture containing far less hydrogen than acetylene, an oil is obtained similar to the Galician petroleum.

These experiments entitle us, in the author's opinion, to conclude that petroleum may be formed in the interior of the earth by the action of hydrogen and acetylene (in varying proportions) on the nickel, cobalt, and iron which undoubtedly exist therein. The origin of the Russian variety of petroleum appears to be inexplicable on any other theory. Moreover, this new theory fits in with all the known facts, and shows how it is that the natural oils of different regions possess different characteristics, chemical and physical, since very slight variations in the process can account for all the differences. Nevertheless, the author does not wish to exclude altogether the organic theory of the genesis of petroleum; he thinks that the oil derived from certain bituminous shales, for instance, which are swarming with fossils, can only be of organic origin. But the organic theory must be abandoned, so far as the American petroleum is concerned. L. L. B.

THE ORIGIN OF PETROLEUM, ETC.

(1) *Zur Frage der Entstehung des Erdöles und der Steinkohlen.* *By* A. F. Stahl. *Chemiker-Zeitung*, 1905, *vol. xxix.*, *No.* 49, 6 *pages*; *and*

(2) *Einige Bemerkungen zum Artikel Prof. H. Potonié's: Zur Frage nach den Urmaterialien der Petrolea.* *By* A. F. Stahl. *Chemiker-Zeitung*, 1906, *vol. xxx.*, *No.* 3, 2 *pages.*

In considering, from the geological point of view, the formations in which workable deposits of petroleum occur, the observer cannot help noticing a distinct petrographical and lithological resemblance between them, to whatever different periods they may respectively belong, and so we are practically entitled to speak of a common "petroleum-facies." The rocks of this facies are predominantly alternating beds, of variable thickness, of marl, shale, clay, sandstone, conglomerate, and limestone, with intercalations of gypsum and rock-salt. The constancy of this facies, moreover, entitles us to assume that the oil therein is a primary deposit, and so the substances from which it was formed must be looked for in that group of rocks. The author holds that these substances were predominantly but not exclusively of animal origin: where great masses of animal organic matter occur, there must be a certain accumulation of vegetable matter also, since such matter constitutes, directly or indirectly, the nutriment of animal organisms. It is not the higher forms of animal life, such as fishes, that furnished the greater part of the material for the world's petroleum-deposits, but rather such microscopic creatures as now swarm in salt-lakes, in certain gulfs and littoral sea-belts, or even in larger pelagic areas (like the Black Sea, the Caspian, or the Sea of Aral), their remains, commingled with clay and sand, forming vast deposits of black mud. For instance, a boring put down in the Inderek salt-lake, on the road from Uralsk to Guryev, has proved black muds, alternating frequently with layers of rock-salt, clay, and sand, for a depth of several hundred yards. The "black muds" of earlier geological periods now present themselves to us in the guise of bituminous shales and slates. The question then arises by what process natural oil was formed from such material. It has been usual to postulate high pressures and possibly high temperatures—but the author regards the distillation-theory as untenable. He points out also, that, even granted simultaneity of great pressure and high temperature, it is chemically impossible to combine into oil or into any compound approximating thereto, the atoms of a mixture of carbon and hydrogen-gases.

In the course of slow decomposition of organic substances sealed up from the air by layers of clay, and subjected to the pressure of the overlying rocks, among other gases large quantities of hydrogen-sulphide are evolved from the albuminous matter and carbon from the cellulose. Now, the organic substances contain a certain amount of iron-oxide, as does also the underground water; but the carbon acts as a reducing-agent, and the iron thus liberated, by reason of its great affinity with the sulphur of the hydrogen-sulphide, combines therewith to form pyrite. Carbon and hydrogen being thus liberated at the same moment, they hasten to recombine, forming the fluid hydro-carbons, otherwise known as petroleum—the quantity thus formed bearing a definite relation to the amount of carbon liberated.

The consequence is, that more or less pyrite is always found in the rocks of the petroleum-facies; where the strata at a subsequent period have been dislocated and subjected to the influence of atmospheric agencies, limonite, or clay-ironstone, or, under certain circumstances, sphærosiderite

is found in them. As an example which confirms his theory, the author cites an occurrence in the petroliferous region of Daghestan, where the iron present in the form of sphærosiderite in a 21-foot bed corresponds to the quantity of carbon sufficient to produce the probable volume of natural oil available in the Tertiary strata there.

From the plant-remains to which the author referred in speaking of the origin of petroleum coal was formed, and he agrees with Dr. H. Potonié in thinking that this happened on the very spot where the plants lived and died, noting in this connexion that the floor of a coal-seam rarely contains distinct plant-impressions while the roof is generally rich therein. Whence it can only be inferred that here the plants grew, new generations arising on the very spot where the old had rotted away, until extensive depressions were filled with peat and a forest-flora; then, sinking below the level of the sea, they were overlain by sedimentary deposits. Similar changes of level are just as manifest in the petroleum-facies as in the coal-measures, but we have in the former, not so much to deal with shallow seas invading the land, as to remember that deep waters often in the former swallowed up the land, and so the overlying deposits are characterized by different features.

For what reason the hydro-carbons derived from vegetable matter are oxidized with greater facility than those derived from animal matter must at present remain an open question, but it is possible that the resins existing in plants have some sort of influence on the chemistry of the process. The variation in character of the petroleums from different beds and different localities may be assignable to the greater or less intermixture of vegetable with animal matter, or to the mechanical intermingling of fats, resins, and wax-like substances elaborated in and from both animal and vegetable organisms.

Just as a certain amount of vegetable matter was undoubtedly commingled with the animal matter from which petroleum was formed, so a certain amount of animal matter was commingled with the plant-remains from which coal was formed: in the decomposition of these plants, microscopic animal organisms played a considerable part. On the whole, there is a remarkable analogy in the origin and process of formation of petroleum and of coal—the conditions were similar, the derivation was organic in both cases, and the sequence of chemical reactions followed much the same course.

In the second paper the author disclaims the view attributed to him by Prof. H. Potonié that the presence of salt was a *sine qua non* in the genesis of petroleum. He merely holds that the freshwater black muds or *sapropels* would hardly yield sufficient material to form workable petroleum-deposits, whereas the salt-water *sapropels* are quantitatively of far greater importance. He does not agree with Prof. Potonié that it is geologically possible to regard natural oil as a distillate from these muds, and he assigns in detail the evidence which militates against that writer's distillation-theory, pointing out that where the necessary heat was to come from is by no means clear. L. L. B.

DIABASES AND PEGMATITES AS MATRICES OF THE DIAMOND.

Neue Feststellungen über das Vorkommen von Diamanten in Diabasen und Pegmatiten. *By* HANS MERENSKY. *Zeitschrift für praktische Geologie*, 1908, *vol. xvi., pages* 155-158.

Until recently, kimberlite was regarded as the sole absolutely undoubted matrix of the diamond, but in October, 1907, the author informed the

Geological Society of South Africa that in the Vaal river-basin, at all events, the diamonds must originate from diabasic rocks: they differ in every respect from all known kimberlite-diamonds. He quotes at considerable length the paper which he read at Johannesburg, and points out with legitimate satisfaction that his views are confirmed by Prof. T. W. E. David's find of diamonds in diabase in Australia.

With regard to pegmatite, Dr. Corstorphine has shown that there is no doubt that pegmatitic dykes are the original matrix of the Somabula diamonds. Diamonds have now, therefore, been shown to occur not only in strictly basic, but in basic-intermediate and acidic rocks. It is also established that olivine and iron-minerals are by no means invariable associates of the diamond in its original matrix. L. L. B.

THE FORMATION OF KAOLIN.

Über Kaolinbildung. *By* H. Stremme. *Zeitschrift für praktische Geologie*, 1908, *vol. xvi., pages* 122-128.

Premising that the protagonists of both the opposing theories of kaolinization which at present chiefly hold the field neglect to adduce experimental chemical data in support of their respective contentions, the author states that he has spent more or less six years in working out the problem from the chemical side. He tabulates first of all analyses exhibiting the contrast in chemical composition between the products of atmospheric weathering of granites and porphyries and those of kaolinization of similar rocks. The considerably greater leaching-out of alkalis and iron in the latter case is conspicuous: granted that both processes are the work of feeble acids, weathering may be generally characterized as a process of oxidation; while kaolinization, so far from being an oxidizing process, may actually be one of reduction. The part played by hydrogen-sulphide in presence of feeble acids, ultimately fixing the iron in the rocks upon which it acts in the form of iron-pyrites, is discussed, as also the conditions under which kaolinization may (in certain cases) be the result of post-volcanic phenomena. For many reasons, adduced in detail, the author holds that certain flat widespread deposits of kaolin or china-clay are the outcome of the action of peat-moor waters on the underlying granites, etc.

He summarizes his main conclusions as follows:—Atmospheric weathering, decomposition by post-volcanic gas-emanations, and decomposition by peaty waters differ therein, that in the process of weathering the iron contained in the rocks is fixed in the form of oxides; that in post-volcanic decomposition, in presence of feeble acids, with abundance of water and exclusion of air, the iron is usually fixed in the form of pyrites; but that in peaty-water decomposition the iron is principally leached out. Consequently, he assumes that kaolin of industrial value is usually formed from ferruginous rocks by the action of peaty waters. In all three processes, carbonic acid is the chief decomposing agent, and so in all three felspar is decomposed to kaolinite; or, if decomposition has not been long continued, it is, at all events, altered "in the direction of kaolinite." Rocks more or less free from iron may also be altered into kaolin by feebly acid gaseous emanations with exclusion of air, or by the chemical agencies of atmospheric weathering. Springs charged with carbonic acid are perhaps among the most potent post-volcanic agents of kaolinization; but thermal waters constituting more or less saturated solutions of salts, instead of decomposing the felspars merely into kaolinite, alter them still further into substances poor in silica. L. L. B.

PRECIOUS GEMS AND RADIO-ACTIVITY.

(1) *Contribution à la Synthèse des Pierres précieuses de la Famille des Aluminides.* *By* F. Bordas. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1907, *vol. cxlv.*, *pages* 710-711.

In nature, the varieties of corundum range from transparent colourless sapphire, through yellow, green, blue, and pink sapphire, to brown and opaque corundum (usually so called), and it is held that this variety of coloration is due to the presence of traces of various metallic oxides (iron, manganese, chromium, titanium, etc.). Recent experiments, however, have led the author to the conclusion that the presence of any particular metallic oxide does not actually determine the coloration of these precious stones. He finds that he can vary their coloration by submitting them to the action of bromide of radium; by graduating the activity of this bromide, or by increasing or decreasing the distance between the precious stone and the radio-active halogen-compound, the intensity of the reaction may be correspondingly diminished or increased. He can make a sapphire pass in this way from the initial red to the violet, thence to the blue and the green, and finally from the green to the yellow. According to this succession of changes, it would appear that the ultimate term of the series is the yellow tinge characteristic of topaz.

The hypothesis suggests itself that in the regions where these precious stones occur, the neighbouring soil (or rock) is endowed with a certain amount of radio-activity. It may be noted that yellow sapphires are the commonest of sapphires, and that sapphires which are in part blue and in part yellow are often found, this bipartite coloration appearing to indicate that the gems undergo in nature a slow modification analogous to that which the author has more rapidly effected in the chemical laboratory.

(2) *Action du Bromure de Radium sur les Pierres précieuses de la Famille des Aluminides.* *By* F. Bordas. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1907, *vol. cxlv.*, *pages* 800-801.

In his second paper concerning the action of highly active bromide of radium upon corundum, Mr. Bordas states that, by a modification of his previous methods, the change of colour can be rendered much quicker and more effective. The gem being immovably fixed in a bit of cork, a tube of radium-bromide in full activity (1,800,000), is brought into direct contact therewith; after a few hours the tube is placed in a different position, in order to obviate spottiness and to spread the new coloration more evenly. In submitting the gem to the action of several sources of radio-activity, the desired result may be attained in the course of a few days. (It is not in the least necessary to wrap the radium-tubes in paper or to place them in darkness.) In this way the author has been able to transform colourless corundum into topaz, to increase the intensity of coloration of natural topaz, as also that of rather faintly-tinged rubies.

Experiments with artificial rubies proved them to undergo the same changes under the influence of radium as the natural ruby, and also showed that radio-activity enables the experimenter to detect the presence of even a trace of metal in a given stone. Further experiments confirmed the view, already expressed, that the coloration-phenomena of stones of the corundum family are not due to the oxidation of metallic oxides.

(3) *Sur la Coloration de certaines Pierres précieuses sous les Influences radio-actives.* *By* DANIEL BERTHELOT. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1907, *vol. cxlv., pages* 818-820.

Mr. Daniel Berthelot, the son of the illustrious chemist recently deceased, gives an account of experiments, on much the same lines as those first described, started by his father on November 15th, 1906, and continued by the son until October 30th, 1907. Colourless quartz and colourless fluorspar showed not the slightest change; but amethystine quartz and violet fluorspar, after being discoloured by artificial means, recovered their lost oxygen when submitted to the action of radium, and resumed their original coloration. The heart of a crystal of the intractable, well cleaved, colourless fluorspar, placed in a saturated solution of acetate of manganese, and then subjected to the action of radium, assumed a pinkish tinge. Apparently the molecular bombardment of the radium-rays carried into the interior of the crystal sufficient traces of metallic salt to colour it slightly. Probably the cleavage-planes facilitate the phenomenon, for there is scarcely any perceptible coloration in the case of a specimen of colourless quartz subjected to the same procedure.

A green emerald from the Tyrol, discoloured by heating in a long narrow tube, failed to resume its original coloration on being exposed to the action of radium. Admitting that the coloration of the natural emerald is due to hydrocarbons, it would seem evident that the organic colouring-agent is irretrievably destroyed by heat.

It may well prove feasible, however, at some future time, to reproduce by means of radio-activity, the natural coloration due to hydrocarbons (such as that of the emerald and of green fluorspar), the electrified radium-rays effecting first of all the synthesis of the colouring-principle and then its diffusion in a colourless crystal, much as fluorspar can be coloured, as above mentioned, at the expense of acetate of manganese. L. L. B.

METALLIFEROUS MINES OF STYRIA, CARINTHIA, AND CARNIOLA, AUSTRIA.

Der Erzbergbau in Steiermark, Kärnten, und Krain. *By* DR. — AHLBURG. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussischen Staate*, 1907, *vol. lv., pages* 463-521, *with* 28 *figures in the text and* 2 *plates.*

In order to elucidate his remarks on this subject, the author considers it prudent to begin with a general synopsis of the geological structure of the Eastern Alps. He points out that no portion of the great Alpine belt shows so clearly the triplicate division into a northern and a southern limestone-belt and a central crystalline-schist *massif*. The northern margin of the central zone is sharply defined by the longitudinal valleys of the Inn, the Salzach, the Enns, the Salza, and the Leitha, but its southern margin, although not deficient in longitudinal river-valleys, is by no means so clearly defined.

Among the ore-deposits of the Eastern Alps those of zinc and lead still rank as of high importance. They are found chiefly in Carinthia, and occur almost exclusively in the Upper Trias. The famous mining centre of Raibl lies not far from the borders of Carniola and Italy in a small transverse valley, cut in the Veneto-Julian Triassic plateau. The deep ravines or *klamme*, which run north and south down from the Königsberg, are the outward expression of the faulting and lateral thrusting which the rocks have undergone, and each of them marks the occurrence of

an ore-deposit within the dolomites. The ores do not bear universally the character of lodes, but assume in some cases a bedded appearance, and a connexion can be traced between them and the "fish-slates" which overlie the dolomites. These ores are predominantly a very pure, markedly pale, blende (often distinguishable only by its weight from the country-rock), and an equally pure galena. In the latter antimony and copper-impurities are conspicuous by their absence, and arsenic is found only in infinitesimal quantity. No gradual passage is observable from the ores into the country-rock, and the hypothesis of metasomatic replacement is therefore excluded. There appears to be, in fact, no doubt that the ores are the result of precipitation from metalliferous solutions within pre-existing cavities in the dolomite. Near the surface oxidic ores occur, among which calamine especially is of industrial importance. The author is inclined to regard all of these as the decomposition-products of the deeper-lying sulphidic ores, whereas Dr. Pošepny ranges them in two categories: one of primary deposition, and the other of secondary deposition. However that may be, there is no question but that the calamine is the outcome of metasomatic replacement of the ore-bearing dolomite; with it is invariably associated brown iron-ore, and occasionally cerussite, silicated zinc-ore, etc. The mineral industry of Raibl dates back to early medieval times: at present the workings belong in part to the Government, and the other part (since the beginning of the 'nineties) to Count Henckel von Donnersmarck. The average monthly output from the latter's mines averages 1,000 tons of smeltable ore, and the main winding-shaft has been sunk to a depth of 460 feet. The extreme variability in thickness of the ore-body constitutes one of the chief difficulties in working. Siemens and Halske's electric drills are in use.

Of equal importance with the mineral-industry of Raibl, and dating back to far more remote times, is that of Bleiberg. The stratigraphical conditions of the deposits are in many respects very similar; but the ores occur principally at the intersections of transverse fissures with certain bands of the Wetterstein dolomite, and thus the form and trend of the ore-bodies here is largely conditioned by the cross-faulting and the bedding. The principal ore is an extremely pure galena, the only impurity in which is an occasional trace of arsenic; blende plays so small a part in these deposits, that it is not even considered in the process of preparing the crude ore. Such blende as the district yields comes from the neighbouring locality of Kreuth. The irregular nature of the occurrences complicates the methods of working.

The lead and zinc ore-deposits of Lower Carinthia are mainly confined to the northern range of the Karawanken, a far-stretching belt of Triassic rocks. The structure of the region is seen to involve, not only simple faulting and thrusting, but a good deal of overthrusting. Much as at Bleiberg, stringers of ore course through certain beds along the lines of disturbance. A peculiarity noticeable in the Miess district is the oft-noted unconformity of the overlying shales to the ore-bearing dolomite, which in reality is assignable to a squeezing-in of the plastic shales (at a later period than that of their deposition) into the fissures of the Wetterstein dolomite. Despite the ease with which the ores are decomposed, owing to the broken-up condition of the rocks, the Miess-Schwarzenbach district bears a great part in the lead-ore production of Carinthia. In 1905, there were 11 mines at work in that province, employing 3,015 workpeople, with an output of 15,193 tons of lead-ore and 21,118 tons of zinc-ore.

Just as the most important lead-and-zinc ore-deposits of the Eastern Alps are centred in Carinthia, so the workable deposits of mercury-ore appear to be confined to Carniola. The world-renowned quicksilver-ores of Idria were discovered in 1490 by woodcutters; after many vicissitudes, the mines were taken over in 1580 by the State, in whose hands they still remain. The tectonics of the district are extremely complicated, but there appears to be no doubt that the deposition of the ores is traceable to a transverse fissure (one of the results of intense post-Cretaceous disturbances) in a mass of Triassic rocks wedged between two great overthrusts. The ores are invariably found, either within the Wengen Shales, or in their immediate neighbourhood, and the shattered condition of these is presumed to have furnished convenient surfaces for the precipitation of the cinnabar from the vapours in which it was borne upwards from great depths. Native mercury occurs at a particular horizon—the Gailthal Shales, which overlie the cinnabar-deposit (in abnormal succession) at the northern margin. The author discusses briefly, and if anything favourably, the prospects of an extension of the ore-bodies both in a southerly direction and in depth. At present, five shafts are in active work, the daily haulage amounting to 400 wagons (a total of 320 metric tons). The entire output is sent to the Government smelting-works, a mile and a quarter down stream from Idria, after a preliminary sorting at the pit-mouth. A detailed description is given of the treatment of the ore (the wet process has long been discarded) and it is stated that the output of metallic mercury from these mines alone in 1905 amounted to over 519 tons. Two other important localities for cinnabar in the same province are cited, Neumarktl in Upper Carinthia, and Littai in Lower Carinthia; but in both cases, after spasmodic revivals, the mineral-industry has been at a standstill for several years. In the Southern Karawanken, however, certain cinnabar-deposits of apparently considerable extent were opened up in the early 'nineties; but the poverty of the ore and the difficulties of transport have checked their further development.

One ore of iron alone, spathic iron-ore, is of supreme importance in the Eastern Alps. To it, however, Austria owes her seemingly inexhaustible wealth in the raw material necessary for the manufacture of iron and steel. It appears to be restricted to three well-defined belts, the most considerable of which (the North Alpine Permian) ranges almost throughout the entire Eastern Alps from Schwaz in Tyrol, passing by Salzburg and the whole of Upper Styria into Lower Austria, attaining its greatest development in the famous Erzberg of Eisenerz. The second and less extensive belt is intercalated among the mica-schists of the central *massif*; while the third and southernmost is associated with the Upper Carboniferous rocks of the Karawanken. Ringed round by mighty hills, the cone of the Styrian Erzberg soars in lofty isolation to a height of 5,040 feet above sea-level: it has been the site of mining operations since time immemorial, and until the second half of the nineteenth century the workings were mainly underground. At the present time these have been entirely given up, and opencast workings are conducted on a colossal scale over a vertical height of 2,000 feet, at 50 separate levels. The annual output between 1891 and 1900 was doubled, a very slight decrease being manifest in recent years (the output for 1905 amounted to 1,064,529 metric tons or about 61 per cent. of the total Austrian output).

Hüttenberg in Carinthia represents the greatest development of the second iron-ore belt. Here too, mining operations date very far back, to the times of the ancient Romans at least. The stratigraphical conditions

are very complicated, and have given rise to many divergent theories concerning the genesis of the ore-deposits. The iron-ores are invariably associated with saccharoidal limestones, which, by dint of taking up mica, pass occasionally into calc-schists: the metalliferous deposits are found sometimes at the contact of the limestones with mica-schists, and exceptionally they wedge out into the mica-schists too. They are of approximately lenticular form, and are very irregular in regard to the horizon at which they occur—that is, whether near the top, or near the bottom, of the limestones. The bulk of the evidence points to metasomatic replacement of the limestone by ores precipitated from thermal waters percolating upwards through fissures in the rock. The mineral-industry hereabouts has greatly dwindled since 1893; in 1905, the number of workpeople employed had shrunk to 176, and the output to 16,649 tons. This is, however, by no means due to any impoverishment of the ores, but to the settled determination of the concessionaires to concentrate their energies on the Styrian Erzberg, where the economic conditions are vastly more favourable for profit-taking.

Little need be said about the iron-ore belt in the Karawanken, since mining operations thereon are in a state of suspended animation; but the ferro-manganiferous ores of the southern flank of the Vigunšica are of noteworthy importance. The ore is a semi-loamy semi-plastic material, containing from 20 to 40 per cent. of manganese, intercalated among the limestones in a band varying in thickness from 6½ to 16 feet. It is most probably of metasomatic origin. Working is conducted (during the summer months only) under primitive conditions.

The remainder of the memoir deals with deposits which are not at present of any considerable industrial importance, such as the abandoned gold-mines, the pyrites-deposits (which are still being worked), the chrome-iron ores of Kraubert, the graphite-deposits of Upper Styria, and the talc-deposits of Mautern in the Liesing valley. L. L. B.

BROWN COALS OF BJELINA, NORTH-EASTERN BOSNIA.

Die Braunkohlenablagerung von Vgljevik bei Bjelina in Nordostbosnien. By Friedrich Katzer. *Berg- und Hüttenmännisches Jahrbuch der k. k. montanistischen Hochschulen zu Leoben und Přibram*, 1907, *vol. lv., pages* 295-336, *with* 4 *figures in the text and a map.*

Bosnia is rich in occurrences of brown coal, but perhaps the most interesting from the scientific point of view and the most important from the industrial point of view is that of Vgljevik-Priboj in the extreme north-east of the country, which forms the subject of Dr. Katzer's memoir. It lies among the highlands which rise sharply more than 1,000 feet above the plain of the Drina and the Save, west of Janja and south-west of Bjelina. Its proximity to two great navigable rivers, to a frontier railway-station, and to the prosperous highly-cultivated "Posavina" (plain of the Save) directed attention to its possibilities immediately after the Austrian occupation; but circumstances, on which the author deems it prudent not to dwell, have retarded the commencement of active mining operations until quite recently.

The geological structure of the district is rather complicated, as it includes a great variety of formations, and has been the site of considerable tectonic disturbance. The oldest rocks belong to the Trias; the limestones and dolomites of this system are not in all cases easily distinguishable

from the overlying Cretaceous Limestones; and these again are, in the weathered condition, very similar to the much more recent (Middle Miocene) Leitha Limestones. The littoral marine Eocene strata cover a vast area, and form practically the basement-rocks of the coal-bearing freshwater Upper Oligocene and Lower Miocene. The Leitha Limestones unconformably overlie the latter as well as the Eocene, and hence it may be inferred that a considerable interval elapsed between the deposition of the brown coals and the invasion of the Middle Miocene sea. The two main epochs of tectonic disturbance in the region were just before the Leitha Limestones were laid down, and immediately after the deposition of the uppermost *Congeria* Beds, that is, probably about the beginning of Quaternary time.

It had been at one time supposed that three coal-basins were in existence, but there is really only one basin, cut up by later disturbances and erosive agencies. The rock-succession therein is divisible into a barren lower group and a productive upper group: the former consists predominantly of red and green mottled clays, soft red sandstones, and conglomerates; the latter of pale-grey marls in places crammed with Cypridea, and green and grey often sandy shales, with the frequently very thick brown-coal seams. Owing to repeated folding and faulting, the brown-coals of Vgljevik-Priboj are split up by the outcropping of the barren group and even of the basement rocks into four distinct "fields"; those (1) of Vucjak-Glinje or Vgljevik proper; (2) of Mezgraja-Jasikovac; (3) of Tobut-Peljave; and (4) of Priboj, ranging from north-east to south-west. The most numerous outcrops of coal occur in the first-mentioned, and generally speaking the seams diminish in thickness towards the south-west, but the quality of the mineral apparently improves in that direction. While in the north-east the seams are associated with cypridiferous marls and overlie mottled clays and rotten quartz-conglomerates, in the south-west they are associated with flaggy freshwater limestones and overlie principally red sandy clays and calcareous conglomerates. It would seem that the Oligocene-Miocene lake-basin in which the brown coals were laid down was filled up progressively from south to north.

A detailed description is given of the four above-mentioned "fields." In the first the two most important seams are respectively 40 and 33 feet thick, and the coal from the thicker seam yielded on partial analysis 10 per cent. of ash, 12·26 per cent. of water at 230° Fahr., 41·82 per cent. residue from vaporization, and a high percentage of sulphur (not stated); heating power=3,971 calories. Analyses are given from other localities, but do not alter much the impression conveyed by the analysis just cited. The second coalfield affords but few favourable exposures, and yet in former years it was the most actively worked of the four. Parts of the main seam here have been (by some unexplained natural phenomenon) "burnt out"; where the coal is in its original condition it is less lignitic than elsewhere, and passes into a sort of "parrot-coal." Analysis of a specimen of a dark brownish-black colour with pitchy lustre yielded the following results:—humidity at 230° Fahr., 16·10 per cent.; ash, 9·66; residue from vaporization, 45·12; heating power, 4,269 calories. In both the fields just mentioned, three groups of seams somewhat compressed together may be distinguished. In the third "field" the bedding is less disturbed, but on the other hand is of deeper-water origin. The stratigraphical conditions are such as to justify the expectation that underground workings here would strike a better and more durable coal than the Vgljevik opencast workings. No outcrop has been found showing a mineral comparable with the 33-foot seam of the

more northerly fields; the 40-foot seam is represented by one which yields coal of variable character: for instance, one layer is of a compact lustrous velvet-black mineral with perfect conchoidal fracture; other layers, although of a rich black and very lustrous, are undoubted lignites of fibrous structure. The heating power ranges from 4,227 to 4,527 calories, and the percentage of ash from 8·05 to 6·40; the lignitic coal contains rather more sulphur than the other. In the fourth coal-field, what is supposed to be the main seam yields a coal of beautiful appearance and good heating power (4,520 calories), yet containing as much as 10·42 per cent. of sulphur. On the other hand, a seam 6½ feet thick exposed in the Corkov valley yields a rich black lustrous coal all but free from sulphur, with only 3·16 per cent. of ash and a heating power of 4,705 calories. On the whole, the Tobut-Peljave and the Priboj "fields" are likely in the near future to be the scene of more active mining operations than the other (at first sight) more favourably circumstanced "fields." L. L. B.

THE FAHLORE AND MERCURY-ORE DEPOSITS OF BOSNIA AND HERZEGOVINA.

Die Fahlerz- und Quecksilbererzlagerstätten Bosniens und der Hercegovina. By Friedrich Katzer. *Berg- und Hüttenmännisches Jahrbuch der k. k. montanistischen Hochschulen zu Leoben und Přibram*, 1907, *vol. lv., pages* 145-265, *with* 25 *figures in the text and* 1 *plate.*

The fahlores take high rank among the useful minerals of the two occupied provinces as, besides being rich in copper, they are also notable mercury-bearing ores. In the world's copper-output fahlores play as a rule a very subordinate part; for, although they may be richly mineralized, their distribution is too restricted, and a good yield of copper from them is only attainable in certain localities; in Bosnia they happen to be of prime importance, and the Maškara smelting-works, for instance, have for many years past been fully taken up with the treatment of fahlores alone. The mercury-ore deposits proper of Bosnia and Herzegovina occur chiefly in the form of lodes and impregnations of cinnabar, and for the time being they are of less industrial importance than the fahlores: no mercury-mine is known to be actually at work in either province. Meanwhile the amount of quicksilver extracted from the fahlores averages 8 metric tons per annum.

The detailed description of the deposits begins with that of Maškara, the only one that has been opened up on an adequate scale. It lies in a region of forests, near the confluence of two streams in the Bugojno district (Central Bosnia). Here phyllites and clay-slates dating back at least to the Carboniferous (impressions of *Neuropteris* have been found at one point) are the most widely distributed rocks, and are succeeded by sandstones, conglomerates, and limestones of Permian age. The probably later fissure-eruptions, of which vast sheets of quartz-porphyry remain as the enduring testimony, may be looked upon as the actual source of the ore-deposits; since it is doubtless from the gaseous exhalations and percolation of thermal waters which took place during the moribund phases of eruptivity that the metalliferous ores were precipitated. The pressure-induced schistosity of the quartz-porphyries here is precisely comparable with that observed among the porphyroid-slates of the Zips-Gömör ore-bearing district in Northern Hungary. The entire mass of rocks above described constitutes a gigantic fault-block or *horst*, abutting by great marginal faults on the north-east against the Cretaceous and on the south-

west against the Trias and the Tertiary. The principal metalliferous lodes belong to a system of fissures striking north-west and south-east, which is intersected by another system striking from north-east and south-west to almost due north and south. Rarely do the troublesome north-east and south-west fissures constitute metalliferous lodes; but the north-and-south fissures are often infilled with the same minerals as the principal lodes, although they are of no considerable extent along the strike, whereas several of the principal lodes can be traced for miles. The lodes cut through all the Palæozoic rocks without their infilling being apparently affected by the passage from one rock-group to another. This independence of the mineralization in regard to the country-rock implies that the force which impelled the upwelling of the metalliferous solutions was very great, and also that the fissures must have extended to considerable depths. The Maškara main lode is infilled with mercury-bearing fahlore, siderite, baryte, quartz, and calcspar; dolomite is of quite subordinate occurrence, and pyrite is rare. Decomposition-products are found, in the shape of limonite hæmatite, malachite, and azurite; chalcopyrite, cinnabar, and metallic mercury seldom occur. Analysis of the pure fahlore has yielded the following results: copper, 38·41 per cent.; antimony, 27·43; mercury, 7·58; sulphur, 21·62; zinc, 0·72; iron, 2·8; magnesia, lead, arsenic, etc., in trifling quantity; 0·005 per cent. of gold; and 0·152 per cent. of silver. Analyses of other samples have yielded as much as 16 per cent. of mercury, with an almost complete absence of arsenic; no single specimen of the ore has been found from which mercury is absent. The main lode is worked by six drifts or adits, spaced over a vertical height of 332 feet. A great extension of the workings is expected in the direction of deeper levels; the smelting-works and the whole installation will then be enlarged, and Maškara promises to become one of the most important centres of the mineral-industry in Bosnia. North-west of that locality, prospecting-work has been done on the metalliferous lodes of Šeferoviči; a selected sample of fahlore from these yielded 35·71 per cent. of copper; 18·37 of antimony; 3·91 of mercury; also 216 grains of gold and 38·26 ounces of silver per metric ton. Farther north-west again, shallow workings have opened up the rich lodes of Mračaj, which are at their richest and thickest while they course through the Permian limestones: the gangue is partly sideritic, partly barytic; but the siderite predominates, and the rich fahlore (the first-formed mineral in the lode) appears to be more especially associated with it. In copper- and in mercury-percentages the ore is quite equal, as the analyses show, to the Maškara mineral. More or less detailed descriptions are given of the fahlores of Dobrošin, Seoci, Rad, Saski Rad, Borova ravine, Cvrće, Djamuš hill, Haslibrdo, Daganj ravine, Valice, Crkvica, Kulentaš hill, Budišna ravine, Parsovići, Koto, Slatina, Orlovac, Dobrigošće, Ježurine, Žaovine, Otomalj hill, Fojnica, Bakovići, Krešcvo, Toplica, Tarćin, etc.

The cinnabar-deposits of the Zec Planina are associated with the nests, stockworks, and beds of hæmatite (probably of metasomatic origin) which occur among the yellow or brownish, cavernous Upper Permian limestones. The cinnabar occurs rarely within the hæmatite itself, but is usually found just above it, in the "roof" or "hanging-wall." Seldom does this cinnabar contain as much as 25 or 30 per cent. of metallic mercury; indeed the general percentage ranges from barely 2 to something over 23. The author assigns the reasons for which he regards these deposits as comparatively superficial; they have been largely worked out, and the attempts made in the years 1889-1892 to follow them up below the limestones met

with results which do not encourage the hope of any permanent revival of mining operations on the Zec Planina. South-east of this massif stretches the Pogorelica Planina, which drops very rapidly to the level of 3,608 feet above the sea: here too, the cinnabar-deposits in the Permian limestones were worked out several years ago, and the same statement would seem to hold good of the deposits of the neighbourhood of Deževica and Kreševo, and of the triple-peaked Inač hill-group. Among the Carboniferous phyllites north-west of Fojnica, a series of six parallel lodes are discerned on each flank of the Cemernica valley, forming together a great metalliferous belt, which can be traced for a distance of a mile and a quarter. The vast intrusions of quartz-porphyry, which have invaded the phyllites some little distance away to the north and west, may no doubt have some more or less direct casual connexion with the mineralization of these lodes. They have been largely worked out by successive generations of miners; but it is by no means certain that mercury was the ore sought for in the olden days. If the opinion advanced by various investigators, that the ancient miners worked these lodes only for the gold and silver which they could get from them, be correct, considerable quantities of cinnabar must be yet lying untouched in the old workings. Indeed, exploration-work in the year 1890 revealed repeatedly unworked portions of lodes rich in mercury. The gangue is of a quartzose character, and the lodes are mineralized chiefly with antimonite, zinc-blende, and cinnabar. Deep-level workings initiated on a large scale are not unlikely to meet with success: the neighbouring country is well watered by streams which have a sufficient fall to keep an electric power-plant going; and enough gold, etc., can be extracted from the old waste (gangue-material) to cover much of the initial expenditure. A description is given of the cinnabar-bearing lode of Zahor, which has, however, been prospected chiefly for its zinc-blende. Far away from the occurrences hitherto enumerated is the Draževici cinnabar-deposit, in the manganese-ore district of Čevljanovič, north of Sarajevo. Its geological conditions are compared by the author with those of the famous Almaden deposit in Spain.

With the exception of the Draževići deposit, all the notable occurrences of fahlore and cinnabar in the occupied provinces are concentrated within a comparatively narrow area—in the slaty or schistose massif of Central Bosnia and its vicinity, untouched as yet by the main routes of communication. Yet most of the deposits are so placed that they could be easily linked up with the chief railway-lines by roads suitable for wheeled traffic, and later on perhaps by light railways. L. L. B.

PETROLEUM AND ASPHALT IN HUNGARY.

Petroleum und Asphalt in Ungarn. *By* Theodor Posewitz. *Mitteilungen aus dem Jahrbuche der Königlichen Ungarischen Geologischen Anstalt*, 1907, *vol. xv., pages* 235-465, *with* 20 *figures in the text and* 1 *plate.*

This monograph is preceded by a bibliography of the subject covering the years 1791 to 1906 inclusive, and comprising no less than 233 entries.

Of the substances with which the author deals, petroleum is perhaps the most widespread in the Magyar kingdom; natural gas has been known for generations to occur at Magyarsáros and the Bázna Spa in Transylvania. Asphalt is found in great quantity at Tataros, Felsöderna, and Bodonos, all in Bihar County; while ozokerite has been traced at comparatively few localities, and then only in small quantity. These bituminous substances are for the most part associated with soft sandstones or sands, and fre-

quently enough with shales. Certain fetid limestones, as at Kolozsvár and Szacsal, moreover, are impregnated with bitumen. South-west of Nagybánya, about 2 miles from the hamlet of Monostor, petroleum and ozokerite are found in limestones, which form inclusions of considerable dimensions within mica-schists. The rhyolite-tuffs of some localities are saturated with bitumen, and in the rhyolitic quartz-trachyte of Kiskapus asphalt occurs filling cavities and fissures of the rock. Finally, at the copper-mines of Recsk, a biotite-hornblende-andesite has been laid bare, with small cavities containing drops of petroleum.

The two chief petroleum-bearing regions of Hungary are situated, one along the north-eastern border, and the other along the south-western border of the kingdom; in age and in structure the beds are as widely different as they are far apart in space. The petroleum-belts in the north-eastern Carpathians, in the counties of Sáros, Zemplén, and Ung, striking parallel one with the other from north-west to south-east, can be followed up across the frontier into the Galician oil-field. In tracing these belts south-eastwards along the inner margin of the Carpathian range, a tremendous break is observed between Máramaros county and the Tölgyes Pass in Transylvania; at the last-named locality the oil-bearing Flysch-beds re-appear, continuing thence uninterruptedly as far as the neighbourhood of Brassó. The Flysch-belt on the outer margin of the Carpathians falls partly within Galician and partly within Rumanian territory, but two petroliferous localities in Hungary belong to this outer margin (Sósmezö and the upper Putna valley in Háromszék county). The south-western oil-field comprises the Muraköz district, Zala county, and Croatia-Slavonia; the two petroliferous belts within it can be traced for mile after mile along the same strike—from north-west to south-east. One of these, extending from Muraköz parallel with the river Drave, is not far short of 50 miles in length; the other runs parallel with the river Save.

The oil-bearing strata of Hungary are predominantly of Tertiary age, but there are a few petroleum-deposits which date as far back as the Trias, the Lias, and the Cretaceous Periods.

A brief history is given of the search for petroleum in the Magyar kingdom, divided into three epochs: (1) that from 1850 to 1880, when such work as was accomplished was merely superficial in character, and was initiated with scant knowledge and less capital; (2) that from 1881 to 1893, when exploration was conducted with some justifiable pretence to technical knowledge, and was backed up by a sufficiency of funds; and (3) that from 1894 to the present day, during which deep borings have been put down, and private enterprise has been strengthened by subsidies from the Hungarian Government. Experience has shown, however, that these subsidies have not made for real progress.

The author gives a detailed description of each of the north-eastern petroliferous areas in the following order: Trenesén county (Turzófalu); Sáros and Zemplén counties; Ung county; Máramaros county; Csík and Háromszék counties; the inner basin of the Transylvanian region; and the north-western margin of the Magyar-Transylvanian frontier-range. He then describes the asphalt-deposits which impregnate the Pontic sands below the drift-clays, at the western base of the Réz hills in Bihar county. Reverting to petroleum he gives a short account of the occurrences in the Mátra range and in the neighbourhood of Nagybánya, followed by a brief description of the bituminous shales of Stájerlak. The south-western petroliferous areas are then described in detail.

Statistics of output are given, showing how unimportant a part Hungary plays as a petroleum-producer: in the single year 1905, Galicia yielded more than 15 times as much mineral oil as had been got from the entire Magyar kingdom in the preceding 45 years. A dozen analyses of petroleum and eight analyses of ozokerite-sands and bituminous shales are tabulated.

In a retrospect of what has been accomplished in regard to the Hungarian oil-fields during the past half-century, the author remarks that unluckily the pen has been far busier than the boring-tool. Actual mining operations are practically confined to the Muraköz district; but the Flysch-belt of the Carpathians has not been thoroughly investigated, and Hungary's possible resources in petroleum remain an open question. Meanwhile the manner in which concessions have been monopolized constitutes a check to mining enterprise. L. L. B.

IRON-ORES OF THE PAYERBACH-REICHENAU DISTRICT, LOWER AUSTRIA.

Die Eisensteinbergbaue der Umgebung von Payerbach-Reichenau (Niederösterreich). *By* KARL REDLICH. *Berg- und Hüttenmännisches Jahrbuch der k. k. montanistischen Hochschulen zu Leoben und Přibram*, 1907, *vol. lv., pages* 267-294, *with* 1 *figure in the text and* 2 *plates.*

After a brief introduction summarizing the literature of the subject, the author gives an account of the history of the mineral-industry in this region, an industry of which the birth dates back many centuries. The earliest time, however, from which documentary evidence is extant is about the middle of the sixteenth century, when apparently the deposits were worked for copper (chalcopyrite) but not for iron. The value of the latter metal was nevertheless fully recognized in the concessions granted before the seventeenth century had drawn to a close and thenceforward, with many vicissitudes and interruptions caused by wars, etc., the industry continued until about 1892, when the stress of modern competition compelled its abandonment. In 1894 a determined effort was made to revive it, but mining operations were finally stopped at Hirschwang in 1902 and at Grillenberg in 1903. Statistics of output are tabulated, covering the period 1719-1903.

Half-an-hour's walk north-east of Payerbach railway-station rises the Grillenberg, a hill chiefly built up of metamorphosed conglomerates among which are intercalated pale slates of similar mineralogical composition. The base of the hill consists of quartz-sericite schists, here tinged green by chlorite and there blackened by graphite: the famous Grillenberg ore-deposit has these schists for its footwall and the conglomerates for its hanging-wall. There are in reality two main ore-belts, striking generally east and west, and dipping northwards, and they have yielded the highest-grade mineral to be got in the district. At Prigglitz, etc., along the eastern prolongation of the Grillenberg, the ores are essentially the same, but show at the outcrop signs of more advanced decomposition. Following the western prolongation of the Grillenberg, one reaches the districts of Hirschwang, Altenberg, and Schendlegg. Here the succession is, in ascending order, grey slates, green slates of diabasic origin, pale slates, massive red and white conglomerates passing upwards into red and green schists: all of which are the outcome of intense metamorphism. With the grey slates is associated the 1st ore-belt, with the pale slates the 2nd ore-belt, and with the conglomerates, etc., the 3rd ore-belt of the area.

The rock-groups already enumerated are of undoubted Palæozoic age, and are overlain by the Triassic (Werfen) shales and limestones. A fault, giving rise to the valley of the Kleinau river, separates the Hirschwang-Altenberg-Kleinau district on the one hand, from the Schendlegg-Schwarzeck district on the other; and the ore-belts, which in the former strike due east and west, in the latter strike north-eastwards. The most considerable output has been obtained from the above-mentioned 3rd ore-belt, which has the coarse conglomerate for its footwall and the red and green schists for its hanging-wall; it is probably of the same age as the Grillenberg ore-deposit and lies at about the same altitude, but, as already stated, at Grillenberg, the slates occur below the ore-body and the conglomerate above it. The workings at Altenberg opened up a deposit 250 feet thick (including partings and unworkable ore) over an uninterrupted length of 350 yards.

The minerals in the above-described deposits include siderite, ankerite, pyrite, chalcopyrite, arsenical pyrite, antimony fahlore, baryte, cinnabar, quartz, calcite, specular iron-ore, limonite, vivianite, azurite, malachite, native copper, etc. The siderite is intimately intermingled with the ankerite in granular masses or in fairly large crystals, and contains on an average 34 per cent. of iron and sometimes as much as 20 per cent. of silica. In 1901, certain ores upon smelting yielded, according to averages spread out over many months, 53 per cent. of the metal. A couple of detailed analyses are tabulated. Next in importance to the siderite is the chalcopyrite, which occurs either impregnating the iron-ore in a very fine state of division or in nodular masses varying in size from that of a man's fist to that of a man's head. The antimony fahlore is intergrown with the chalcopyrite; it is of a pale steel-grey colour, and analyses show that it contains a certain amount of gold and silver.

Discussing generally the origin of the ore-deposits in this sub-Alpine region, the author arrives at the following conclusions:—The siderite-chalcopyrite deposits are practically conformable with the Palæozoic strata among which they occur, they show none of the symmetrical arrangement appertaining to lodes, and must consequently be regarded as epigenetic. They are almost invariably associated with eruptive rocks, such as diabases and their derivative tuffs or quartz-porphyries and their derivative tuffs. Two categories of such deposits may be distinguished, the slate or schist-type (to which those here described belong) and the limestone-type.

L. L. B.

THE ROSSITZ COAL-FIELD, MORAVIA, AUSTRIA.

Die Tektonik des Steinkohlengebietes von Rossitz und der Ostrand des böhmischen Grundgebirges. By FRANZ E. SUESS. *Jahrbuch der kaiserlich-königlichen geologischen Reichsanstalt*, 1907, *vol. lvii., pages* 793-834, *with* 2 *figures in the text and* 2 *plates.*

There is a strip of the Rothliegende formation which extends for some 93 miles from Senftenberg in Bohemia, through Mährisch-Trübau, Boskowitz, and Rossitz, as far as Mährisch-Kromau, and its tectonic importance, as demarcating the boundary between the ancient crystalline schists of the Bohemian massif on the west and the older Palæozoic plications of the Sudetic ranges with the Brünn intrusive mass on the east, did not escape the earlier observers. Recently, Dr. Tietze has applied to this long and narrow *graben* or *fosse* the appellation of the "Boskowitz rift," drawing

attention to its connexion with those post-Cretaceous disturbances which resulted in the upheaval of the Sudetic ranges and the Riesengebirge, and also to the bifurcation of the rift northwards into two parallel *gräben* or *fosses*. In the present memoir the author deals almost exclusively with the tectonic details of the southern portion of the rift, and with the extension of the main tectonic features beyond its southern termination as far as the neighbourhood of Znaim.

By far the greater portion of the Boskowitz rift is filled up with the red and grey sandstones, and thinly-bedded shales and occasional conglomerates, which are all assignable to the Rothliegende; but from Rziczan near Rossitz southwards these are succeeded by the underlying coal-bearing sandstones and enormous masses of conglomerates, determined as being of Coal-measure age. Dr. Katzer, in a recent review of the flora of the Rossitz seams, has found undoubted Permian as well as Upper Coal-measure plants therein; indeed, the occurrence of *Walchia pinniformis* in the middle seam predisposed him to claim the entire formation as Permian. But Dr. Weithofer points out that the premature occurrence of some isolated Permian plants hardly justifies so drastic a conclusion, and holds that the seams belong to the uppermost Coal-measures or Radowitz Group; he adds that the true Permian flora only begins above the roof of the topmost coal-seam. Some authors have included the coal-bearing horizons and the Rothliegende in one formation as Permo-Carboniferous, and although Dr. F. E. Suess, following the late Dionys Stur and Dr. Weithofer, separates the coal-bearing group as Upper Carboniferous from the Rothliegende, he retains an open mind as to the true stratigraphical relationship of these measures. He regards them as largely of desertic origin, drawing a comparison between them and the coal-basins of the Central Plateau of France, down to the minutest details of sedimentation. The basement-conglomerates attain a thickness exceeding 660 feet; they are overlain by sandstones (often extremely felspathic) with intercalated thinly-bedded shales, and some 70 feet up in these is the third or lowest coal-seam, hardly workable, but very rich in plant-remains. This is overlain by about 165 feet of multi-coloured sandstones with intercalations of thinly-bedded shales and some conglomerates, when the somewhat thicker second seam is reached. A thickness of some 400 feet of sandstones with a few conglomerate-bands separates this from the first or main seam, above which mainly red flaggy sandstones and shales in frequent alternations constitute a passage into the Rothliegende formation. Apart from numerous small faults and from the tectonic disturbances in the north at Okrouhlik and in the south at Neudorf, the coal-bearing group of rocks presents the aspect of a semi-syncline dipping steeply eastwards: this inclination is due to sagging subsequent to deposition. The main seam was at one time worked to a thickness of 2½ to 3¼ feet in the Ferdinand pit, and at Okrouhlik, north of Segengottes; but in these localities there are many shaly partings and local "nip-outs." Increasing in thickness southwards, the seam attains 13 feet at Babitz and Zbeschau, and exceeds 20 feet at Padochau (near which the original centre of the half-preserved syncline probably lay). At Oslawan, however, the thickness already diminishes to 10 or 12 feet, and the records of the now abandoned workings at Neudorf show that the seam was there only from 2½ to 3¼ feet thick. The much thinner second (or middle) seam follows the same course of variation as the main seam.

The Rothliegende sediments are also fully described: they include two

horizons of bituminous shale, one of which is especially rich in fish-remains, and in reality fall naturally into the same group as the coal-bearing rocks.

With regard to the possible opening-up of the main seam in the as yet unexplored portions of the area, the prospects in the south, at all events, are not hopeful. Nor are they more favourable in the east; the most probable extension of the coalfield may be looked for on the north, under the Rothliegende strata at Rziczan, but even here the decrease in the thickness of both the seams and the basement-beds north of Segengottes rather implies approximation to the rim of the old basin. L. L. B.

THE AURIFEROUS ROCKS OF TRANSYLVANIA.

Das Goldvorkommen im Siebenbürgischen Erzgebirge und sein Verhältniss zum Nebengestein der Gänge. *By* M. von Pálfy. *Zeitschrift für praktische Geologie*, 1907, *vol. xv., pages* 144-148, *with* 3 *figures in the text.*

One of the main problems to which the author addresses himself in this paper is the question whether the country-rock is a determining factor in the infilling of lodes which yield the precious metals, and, if so, in what manner its determining influence is exhibited.

Premising that, until recently, all the lodes in the Transylvanian Erzgebirge had been regarded as the infilling of contraction-fissures which supervened in the mass of molten eruptive rock in process of cooling, he asserts most positively that his detailed investigations now prove these fissures to be in all cases of tectonic origin, and their strike coincides with the two main directions of those lines of tectonic movement that can be traced throughout the mountain-*massif* above-mentioned.

As to the source of the precious metals in the lodes, it must be sought in the hundreds of volcanic necks which are scattered over this Erzgebirge. In the later phases of vulcanicity, the upwelling gases and vapours undoubtedly precipitated the metallic particles with which they were charged in the vicinity of these necks. The hypothesis, according to which the precious metals were already existing in an extremely-fine state of division in the eruptive rocks cannot, for several reasons, be sustained. The lodes are only auriferous down to certain (it is true, variable) depths; but the gold does not occur even as low down as sea-level, whereas, if the above-mentioned hypothesis were true, enrichment ought to keep pace with depth—or at least the lodes ought to be gold-bearing much deeper down than is the case. It will be observed that, generally speaking, the precious metals in the Transylvanian Erzgebirge do not occur actually within the volcanic necks, but mostly along their margins or in the country-rock immediately adjacent thereto. As the distance from a volcanic neck increases, the amount of precious metal in the lodes decreases, more or less rapidly. The author's view is based on an examination of the rocks exposed in every single mine in the district, and he holds that it is now possible to say with absolute certainty at what localities precious metals may be looked for—bearing in mind, of course, the possibility that the vapours or gases emanating from the "necks" in the moribund phase of vulcanicity did not in every case carry particles of precious metal.

At Nagyág, the lodes course partly through a neck, partly through its capping of soft decomposed lava and Mediterranean (Tertiary) deposits. The precious metals are exclusively obtained from this "cover" of decomposed lava, and only in the vicinity of the neck. In all the other

localities cited, stress is repeatedly laid upon the fact that it is the vicinity of the neck which is important, rather than the nature of the country-rocks—these include andesites, dacites, liparites, lava-flows, tuffs, breccias, melaphyres, Carpathian sandstones, and Mediterranean shales; and at Ottenbánya crystalline schists and limestones. L. L. B.

NATIVE COPPER IN THE FÆRÖE BASALTS.

Über das Vorkommen von gediegenem Kupfer in den Trappbasalten der Farörinseln By F. Cornu. *Zeitschrift für praktische Geologie*, 1907, *vol. xv.*, *page* 321-323.

After a brief conspectus of the literature of the subject, the occurrences of native copper having been observed as far back as the latter half of the seventeenth century, the author gives a general account of the geology of the Færöe (Islands) which he visited in the summer of 1907. This is far from complicated, as that remote archipelago is built up of great basalt-flows of early Tertiary age, among which are intercalated thin bands of red-burnt ash. On Suderöe and Myggenaes there occur also some interbanded layers of clay with coal-seams. The general dip is south-easterly.

With regard to native copper, the author examined the localities on Naalsöe, an island lying opposite Thorshavn, the capital of the Færöe. The inhabitants are well aware of the occurrence of the metal, and masses now and then found on the beach have been worked up by native artificers. But the widespread belief among them that the copper is auriferous and that gold may yet be discovered on Naalsöe is absolutely unfounded. The copper itself is, on the whole, so sparsely distributed in the basalts that no encouragement can be given to the idea of working it for commercial purposes. The metal is found in druses, associated with various zeolites which appear to have crystallized out later than it.

South-east of Trangisvaag on Suderöe, on the way to Frodeböenyper, the author observed at the outcrop of a coal-seam on the shore at Frodeböe a compact black "trap-basalt" forming the immediate roof of the seam, and containing native copper in large zeolitic amygdules. The copper always occurs at the base of the amygdules, having either a granular or a lenticulated structure. On the very next day, on the shore north of Famien, he observed an exactly similar occurrence.

The characteristic features of the occurrences of native copper in the Færöe (not only those visited by the author, but also those described to him by residents, which he was debarred by stress of weather from investigating personally) are the association with zeolites and the absence of the sulphides of the metal. Dr. E. Hussak has described native copper as occurring in the amygdules of a diabase from São Paulo, and has attributed its origin to the decomposition of chalcopyrite distributed through the rock in a finely-divided state, although not a trace of copper can be actually found in the diabase itself. This explanation will not (the author thinks) fit the Færöe occurrences, but he will not commit himself to any other hypothesis as to their genesis. All that can be safely postulated is that, like the later zeolites, the copper is a product of the moribund phase of vulcanicity, deposited from the same solution as they subsequently were deposited, in cavities in the basalts. L. L. B.

THE SEARCH FOR COAL IN FRANCHE-COMTÉ, EASTERN FRANCE.

Les Recherches de Houille en Franche-Comté: le Massif de Saulnot et sa Bordure. *By* EUGÈNE FOURNIER. *Bulletin de la Société Géologique de France, series* 4, 1907, *vol. vii., pages* 517-524, *with* 1 *figure in the text.*

South of the Trias which overlaps the Permian strata forming the southern limit of the Ronchamp coal-basin, there is a small outcrop of metamorphic Devonian schists to which the author gives the appellation of the Saulnot *massif*: against it abut, south of Chenebier, the Culm-measures. Now, as similar Devonian and Culm rocks appear on the northern margin of the Ronchamp coal-basin at the southern extremity of the Vosges, it was hoped that borings put down in the Permo-Triassic area north of the Saulnot massif would strike at some unknown depth the presumed southerly extension of that coal-basin. The author was called upon in 1902 to give his opinion as to the probable results of a borehole put down at Lomont: various geologists had asserted that the site could not have been worse chosen, and that the Devonian would be reached at a depth of 1,300 feet. The author, however, rightly predicted the occurrence of coal-seams somewhere between 3,440 and 3,600 feet. The first venules of coal were struck at 3,365 feet; and at a depth of 3,575 feet, the bore commenced passing through a group of coal-seams, some of which were respectively 4 feet, 5½ feet, and 6 feet thick (the last-mentioned seam at the depth of 3,610 feet). About 22½ feet lower down the boring-tool remained fast in black shales, the character of which indicated the neighbourhood of another coal-seam group of Stephanian age.

The author assigns the reasons for which he considered that any attempt to strike coal at a shallower depth near the Saulnot *massif* was foredoomed to failure, and the untoward results of the Courmont boring, stopped at a depth of 3,503 feet, confirmed his forebodings. Down to 2,952 feet eruptive rocks of Permian and possibly Upper Coal-measure age were passed through: in all, the thickness of the Coal-measures passed through was estimated at 500 feet, but not a single coal-seam was struck, and the boring was stopped in green porphyritic tuffs (supposedly of Culm age). It is held that the search for coal should be continued at a distance of at least 2 miles north of the Saulnot *massif*, in the neighbourhood of Lomont and north of Faymont, but that investigations should not be pursued too far to the eastward. The coal-basin would appear to deepen and increase in dimensions westward; but researches conducted too far in that direction also would be of little avail, as the coal would be struck at an impracticable depth for mining operations. Thus a boring put down at Frotey-les-Lure continued in the Permian down to a depth of 4,100 feet. The workable seams of the Lomont basin, for which a concession was granted in 1904, are estimated to extend over a length of 3¾ miles, parallel to the margin of the Saulnot *massif*, and over a breadth of not less than 2 miles. They will be worked between the depths of 3,440 and 3,770 feet, and in thickness and quality are comparable with those of Ronchamp. A deposit of malachite and azurite was discovered in the course of the boring operations, at two points in the Valettes ravine near Courmont, among arkoses and microgranulitic tuffs of Lower Permian age. The deposit is undoubtedly sedimentary and of lenticular character, and in the author's view exploration-work upon it has been abandoned too hastily, as it is a certain indication of the existence in depth of a lode of sulphidic ores which might repay working.

South of the Saulnot *massif* the stratigraphical succession is absolutely normal: a boring put down at Chevret was stopped in the Muschelkalk at a depth of 1,476 feet. If Coal-measures occur on that side of the anticline, they cannot be struck at a depth less than 3,610 feet from the surface.

L. L. B.

COATQUIDAN IRON-ORES, BRITANNY.

Sur le Minerai de Fer de Coatquidan. *By* F. Kerforne. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1908, *vol. cxlvi.*, *pages* 1226-1227.

The Coatquidan iron-ore deposit, in the department of Morbihan, was first worked in 1825, but has now been abandoned for some little time. Its output was used in the iron-works of Paimpont. The deposit would appear to lie at a geological horizon marking the division between the Cambrian pink grits and claret-coloured shales, and the Ordovician white grits, practically at the base of the Armorican Grit. It dips very slightly north-westwards, and in thickness occasionally attains a maximum of 6½ feet. The ore, a red hæmatite, not seldom earthy, but most frequently granular, appears to be built up of flattened irregular granules with a black patina, immersed in a red ore of finer texture containing a fairly considerable amount of minute grains of quartz. In places this particularity is so exaggerated that the deposit presents rounded nodules of hæmatite of extremely irregular shape immersed in a ferruginous mass with big quartz-grains, forming, in fact, a sort of conglomerate. The Coatquidan ore differs, then, in character, from most of the known iron-ores of Britanny and Normandy, the only deposit that is at all similar to it occurring at Caden, farther south.

L. L. B.

ORDOVICIAN IRON-ORES OF LOWER NORMANDY.

Note sur le Minerai de Fer silurien de Basse-Normandie. *By* Ch. E. Heurteau. *Annales des Mines*, *series* 10, 1907, *vol. xi.*, *pages* 613-668, *with* 7 *figures in the text and* 3 *plates.*

The iron-ores worked in the Lower Normandy departments of the Calvados, the Orne, and the Manche, occur in the *Calymene* Slates (or Angers Slates) either at about 130 or 150 feet above the base thereof, or at the base itself close to the junction with the underlying Armorican Grits. The Cambrian, Ordovician and Silurian systems in this region have a generally parallel orientation, trending about N. 115° E. in the Calvados and Orne, and approximating to an easterly and westerly trend in the Manche. They form a series of more or less regular, more or less complete synclines, masked on the east by the Jurassic deposits beneath which they dip slightly, while on the west they appear amid the pre-Cambrian phyllites or in contact with masses of eruptive rock. The general structure has been much complicated by folding and faulting, and by the subsequent erosion. The ore is in places hæmatite, elsewhere it is a carbonate of iron, and elsewhere again it is a mixture of the two. It may be said, on the whole, that the deepest-lying portions of the ore-body are carbonated, the hæmatite occurring only in the vicinity of the outcrops. It would appear that originally the ore was entirely deposited as a carbonate, that oxidation was induced by the percolation of surface-waters, and that the limit of such oxidizing action must have been determined by a particular hydrostatic level. But the underground water-level

of the present day gives no reliable clue; the ancient hydrostatic levels require to be traced out (if that were possible), in order to determine the limiting-level of the action which in ages gone by oxidized the carbonate to hæmatite. These Ordovician ores have been struck, and are worked along four synclines, which are, proceeding from north to south: (1) the syncline of St. André and May-sur-Orne; (2) the Perrières-Barbery syncline, passing through La Brèche au Diable; (3) the Falaise syncline, passing through St. Rémy and Jurques; and (4) the La Motte Forest-Mortain syncline, with which connects an important ramification extending northwards to La Ferrière-aux-Étangs and Halouze.

The workings of the May mine, on the southern rim of the first syncline, have followed up the ore-body for more than a mile and a quarter to the east of the river Orne; although the ore-body approaches 20 feet in thickness, it is too highly silicified to allow of more than 6½ feet being worked, and that near the foot-wall. As deep as the workings have gone, that is, down to 115 feet below the river-level, the ore is hæmatized. The silica often invades the lower portion of the ore-body in such a fashion that it can be regarded at its base as richly metalliferous only in irregular patches separated by siliceous areas. The dip varies from 45 to 50 degrees. At St. André, still on the right bank of the Orne, but on the northern rim of the syncline, the ore-body seems to be well nigh vertical, with, in places, a reversed northerly dip. As at May, it is some 20 feet thick, the richer portion, near the footwall, measuring from 8¼ to 10 feet in thickness, the remainder being practically non-payable ore: workings pushed some yards below the river-level here have disclosed a diminution in thickness of the hæmatite, the rest of the ore being then unmistakably a carbonate. The parallel outcrops of May and St. André, some 1,420 yards apart, are concealed by the Jurassic rocks, and are faulted by a few unimportant dislocations.

The eastern limit of the Perrières-Barbery syncline follows a normal course and is well known, but its western boundary is masked by the Clay-with-Flints of the Forest of Cinglais. Two rivers (the Laize and the Laizon), entering the basin by deep gorges cut in the Armorican Grit on its southern margin, reveal therein the ore-body, the outcrop of which is smothered on the plateau by 70 to 130 feet of Jurassic beds. The ore-deposit lies in the *Calymene*-slates, some 150 feet above the Armorican Grit, and is mineralized over a thickness of 16½ to 20 feet; but its percentage in iron and its general character are somewhat irregular. The hæmatized portions lie near the footwall, rarely exceeding 6½ feet in thickness, and averaging 5 feet. Frequently the hæmatite gives place to grit or to clay, and indeed only occurs immediately beneath the Jurassic covering-rocks: 60 or 70 feet lower down, it appears to be everywhere replaced by carbonated ore, and occasionally the carbonates reach up to the Jurassic. In point of fact, the deposit may be shortly described as a basin of carbonate, the margins of which are irregularly hæmatized, the hæmatite being generally of a rather earthy nature. The mean dip is 50 degrees; borings, at the time of writing, were in progress, with the view of determining whether the ore-deposit flattens out in depth.

The Falaise-St. Rémy-Jurques syncline is of a more complicated structure than the two just described: the *Calymene* Slates are, in places, unrecognizable, and the ore-body is not always met with just where it might be expected. What with oscillations of the crests of a double syncline, and what with numerous longitudinal and transverse faults, the Ordovician

basin has been cut up into, as it were, a series of islets, or separate inliers. In the St. Rémy mines the ore-deposit is found at the junction of the Armorican Grit and the *Calymene* Slates: it is entirely hæmatized, its percentage of iron (52 to 53, the highest in the region) is very constant, and its thickness (also extremely regular) ranges between $8\frac{1}{4}$ and 9 feet. Exploration-work farther west, on the Montpinçon hill, has not yet revealed there the existence of a workable ore-deposit: the hæmatite can be followed for a few yards, is then lost, and re-appears from place to place, varying in thickness from a few inches to 5 feet. At Jurques, a band of carbonated ore, dipping from 55 to 68 degrees northward, 3 to 4 feet thick, has been struck just above the Armorican Grit.

The Bagnoles-Mortain syncline ramifies into two in the neighbourhood of the Mont-en-Gérome. With a few local exceptions, the ore-band occurs at the junction with the Armorican Grit, and is hæmatized in places. In the Forest of Halouze, the continuous Ordovician outcrop is traceable for about $2\frac{1}{2}$ miles: the ore-body here is almost vertical and exceeds 13 feet in thickness.

The hæmatized ores in this region have been worked for many generations, and the ancient workings have served as useful indicators for the modern concessionaires. The first of the more recent concessions (St. Rémy) dates from 1875, and was enlarged in 1884 by the Halouze concession; but it was not until the metallurgical "boom" of 1900 or thereabouts that exploration-work was directed to the less accessible portions of this great series of ore-deposits. Since 1895 the annual output from the St. Rémy mines has ranged between 95,000 and 110,000 metric tons. The pillar-system of working, leaving 9 per cent. of the ore in place, has had to be abandoned as too dangerous, and under present conditions from 15 to 16 per cent. of the ore is left (some, at least, of which may be got later). The stuff is brought down by means of dynamite. The St. André mine showed in 1906 an output of 27,971 tons; but this hardly represents its full capabilities, as perhaps the richest part of the ore-body there has still to be explored. The May mine yielded 75,000 tons in 1906: the ore is worked on the very bank of the river Orne, across which it is carried by telpherage, and emptied from hoppers into the trucks of the Western Railway Company. When the richer portions of the deposit near the outcrop now being worked in this mine are exhausted, it seems probable that deeper down richly hæmatized or carbonated lenticles will be eventually struck. The La Ferrière-aux-Étangs mine, started only in 1902, yielded in 1906 about 81,000 metric tons of ore, calcined on the spot in four furnaces, which are linked up by a private railway with the line from Caen to Laval at the station of St. Bomer. A full list is given of the concessions, 20 in number, covering a total area of 37,480 acres in the region.

It has already been noted that the hæmatite of St. Rémy is the richest, containing from 52 to 53 per cent. of metallic iron; the hæmatites of May and St. André occasionally attain a percentage of 51, but the average varies between 47 and 48, and frequently ore is worked which only contains 46 per cent. of the metal. Silica, which at St. Rémy ranges between 10 and 12 per cent., averages 14 per cent. in the other mines. The percentage of phosphorus is everywhere much the same, from 0·6 to 0·7. The ore from none of the three mines just mentioned, nor from that of Barbery, requires any special preparation for selling purposes. The typical carbonate (say, that of La Ferrière) contains rather more than 40 per cent. of metallic iron, 10 per cent. of silica, 0·67 of phosphorus, 0·32 of manganese,

4·5 of lime and magnesia, 4·3 of alumina, and the loss on ignition is 26·6. The percentage of iron at La Ferrière tends apparently to increase as the workings reach deeper-lying horizons, and often exceeds 51; the lime also increases slightly with the depth. The cost-price of the hæmatite delivered into the railway-trucks is reckoned by the author as 5 francs or 4s. 2d. per metric ton; that of the crude carbonate as about 2s. 9d.; and that of the calcined carbonate as about 5s.

The ores are to a large extent shipped from Caen to Great Britain and Germany; the author devotes an entire chapter to the consideration of the manner in which this export is effected, and points out incidentally how the Rotterdam shipowners have contrived to monopolize the sale of iron-ore in Westphalia and have even extended their operations to the British market. Practically the only variety of Lower Normandy ore now utilized in the north of France is the calcined carbonate, got from concessions belonging to the Denain and Anzin Steelworks Company. L. L. B.

BROWN-COAL DEPOSITS OF THE HOHER WESTERWALD, GERMANY.

Die Braunkohlenlagerstätten des Hohen Westerwaldes, unter besonderer Berücksichtigung ihrer wirtschaftlichen Verhältnisse. By F. Freise. *Zeitschrift für praktische Geologie*, 1908, *vol. xvi., pages* 225-237.

By a singular concatenation of circumstances these deposits, which, considering their extent, their quality, and the availability near at hand of natural resources favouring mining operations, should under ordinary conditions, have given rise to an active mineral-industry on the grand scale, have been until quite recently worked only just enough to supply a purely local demand. The concessions were split up among small or unenterprizing capitalists; transport-facilities were defective; and markets ready to absorb a large output were the less easy to find, in view of the enormous recent development of the German bituminous coal-industry and its consequent overwhelming competition with the brown-coal industry. Many of these difficulties have now, however, been overcome, and the author foresees a brilliant future for the mining-field which he describes.

The Hoher Westerwald is a table-land rising from a minimum level of 720 to a maximum level of 2,200 feet above the sea, dropping rapidly towards the Heller valley on the north, and towards the Dill valley on the east, but sloping very gradually southwards and westwards to the Rhine and the Lahn. The rocks of the district include, besides the lignite- or brown-coal seams, clays, quartzites, sands, quartz-gravels, conglomerates, tuffs, pumiceous rocks, and basalts. The last-named are mostly plagioclase-basalts, rarely nephelinic: they extend for more than 18½ miles from north to south, and for about 22 miles from east to west. Two main flows are distinguishable: the older, lying below the brown-coal group, is known as the "floor-basalt," and the younger, coming above that group, is known as the "roof-basalt." The clays are perhaps the most considerably developed of the sedimentary deposits, both above and below the brown-coal seams, and thin layers of them are interbanded with these. In several localities the clays are indurated into a tough material with conchoidal fracture; and in some few localities, where they have preserved their full plasticity, and contain but little iron-oxide and coaly matter, they are of industrial value. The brown coals or lignites have a brown to a pitch-black coloration, flaky to smooth fracture, and are rather splintery. Their percentage composition, taking the mean of forty analyses, is as follows:—Carbon, 58 to

70; hydrogen, 5 to 6½; oxygen and nitrogen, 11 to 20; hygroscopic water, 32 to 42; ash, 2 to 6. On drying in atmospheric air, the mineral loses from 20 to 22 per cent. of water, and flakes away easily. Its heating power, when freed from water, ranges from 7,100 to 7,250 calories; and in this respect, therefore, it is almost comparable with the best bituminous coals. The author made coke from it experimentally, and found that picked samples of the best grade of the mineral yielded 55·38 per cent. of coke, fairly compact and tough. The Westerwald lignites by themselves cannot be used for the production of illuminating gas, but they form an admirable adjunct to the ordinary gas-coal when mixed with it for gas-manufacturing purposes. Plant-remains, including maple, oak, alder, poplar, willow, elm, laurel, etc., are abundant; but the sole animal-organism found in the brown-coal seams is represented by the scales of *Leuciscus papyraceus*. On the whole, these deposits occupy a deep basin hollowed out in the Devonian rocks, striking north-east and south-west, and measuring in its greatest breadth (from Marienberg to Mengerskirchen) about 11 miles. The comparatively steep dip of the underlying basalt-conglomerates leads irresistibly to the inference that the filling-up of this basin was accomplished at repeated intervals; the successive layers of deposition are seen to become gradually flatter, until at the horizon of the brown-coal seams they are all but horizontal. The conglomerates lessen in coarseness upwards, until just below the seams they pass into hard sandy clays among which are sparsely scattered occasional fragments of basalt. The strata of the brown-coal group, partly as a result of the basalt-outpourings (which continued, as we have seen, after the deposition of the lignitic seams), and partly as a result of the disappearence of the clays and the continuous sagging of the basin, are broken up by enormous fissures into "fault-blocks" of varying mass. Most of the underground workings that have been systematically explored show from three to six seams, ranging in thickness from something over a couple of inches to 13 feet or so. Generally two seams alone, and those the lowest in the series, can be regarded as workable. The Wilhelm mine at Bach is unique in having proved three workable seams.

The mining field comprises 130 concessions, covering an area of 90 square miles: out of this, only about 2 square miles have been opened up and in part worked; but, on the other hand, the concessions as a matter of fact include a vast amount of barren ground. A more or less detailed description is given of about a dozen mines (concessions covering 7 square miles): on these concessions in 1906 and 1907 boring operations, directed to the discovery of fresh stores of lignite, were systematically carried out down to a maximum depth of 500 feet below the surface, and at two localities a workable coal-supply was struck at two different horizons.

As long ago as 1585 the first shaft for brown-coal was sunk in the Westerwald, and the author traces briefly the vicissitudes of the industry through the following two centuries. Coming to our own day, he remarks that mining operations worthy of mention are confined to the Alexandria mine at Höhn, the Government mine Oranien, on the Black Nister river, and two mines in the Dill district. The total number of workpeople employed thereon in 1906 was 249, and the output for that year was 33,369 metric tons valued at £14,208. The statistics of output from 1891 to 1906, both years inclusive, show but small variations, and any distinct tendency to increase is only observable from 1903 onwards. After a rather dismal survey of the labour-conditions of the Westerwald, in regard both to quality and to quantity, the author proceeds to a careful estimate of the

probable amount of brown-coal actually available in that area: he himself says that, in the absence of detailed and systematic exploration-work, his figure of 982,041,720 cubic feet (or 20,237,970 tons, according to the weight stated for a cubic metre of the mineral at an earlier stage of the paper), must be accepted with due reserve. L. L. B.

POSSIBLE NEW COAL-FIELDS IN THE ERZGEBIRGE REGION, GERMANY.

Über die Möglichkeit der Aufschliessung neuer Steinkohlenfelder im erzgebirgischen Becken. *By* C. GÄBERT. *Zeitschrift für praktische Geologie*, 1908, *vol. xvi., pages* 114-119, *with a map in the text.*

Coal-mining in this region is principally centred in the Zwickau-Bockwa-Oberhohndorf district and in the Lugau-Würschnitz-Œlsnitz district; in the former, the coal-seams are now all but worked out, and in the latter the amount of coal in sight is diminishing at so fast a rate that the kingdom of Saxony will cease to occupy a place in the list of coal-producing countries, unless fresh coal-fields are meanwhile opened up. For several years strenuous endeavours in this direction have been made, but have met so far with almost negative results. Details are now published, for the first time, of three deep borings put down during the years 1899-1905, in the neighbourhood of Oberzschocken, in the presumed south-western extension of the Würschnitz coal-field. The deepest, going down to 3,575 feet below the surface, passed through 370 feet of Coal-measures with five thin seams (ranging from 2½ to 34 inches in thickness); the second, terminating in the fundamental rocks at the depth of 2,395 feet, passed through 210 feet of completely barren Coal-measures; and the third, terminating similarly in the fundamental rocks at the depth of 2,318 feet, passed through 103 feet of Coal-measures yielding mere traces of coal. These results were the more disappointing that the second and third borings are respectively distant but two-thirds of a mile, and barely one mile from the Œlsnitz-Vereinsglück collieries, where a seam from 10 to 16 feet in thickness is being worked; and the opinion has been expressed that these borings must have pitched precisely on faults or nip-outs, passing (very likely) quite close to workable coal-seams. With regard to the first boring, situated 1¼ miles south-west of the now abandoned Frischglück shaft, favourable results were perhaps hardly to be expected, as in that shaft, out of a total depth of 2,752 feet, only 295 feet can be assigned to the Coal-measures, with four seams ranging in thickness from 4½ to 40 inches. Thus, at two points at great depths within an extensive coal-basin, we find that seams which are of considerable thickness towards the southern and eastern margins, wedge out towards the centre of the basin, in which direction they show a constant but low dip. The advisability seems indicated of further boring operations, in the Niederzschocken flats, south-west of the above-mentioned second and third borings, and not too far from the rim of the coal-basin.

In the summer of 1907 a boring was put down in the Neukirchen plain, north-east of Lugau, striking the Coal-measures at the depth of 1,027 feet, and passing out of them into the Cambrian slates 174 feet lower down (that is, at 1,201 feet). A seam of very pure coal about 20 inches thick was found in this boring, as well as venules of coal at various horizons. The stratigraphical details of this boring, when coupled with the results, only recently rediscovered, of a boring put down north-east of

Leukersdorf as long ago as 1863, indicate that it is in the Leukersdorf-Neukirchen area that those who are looking for an extension of the Lugau coal-field should pursue their investigations. L. L. B.

THE GOVERNMENT COLLIERIES IN THE SAARE DISTRICT, GERMANY.

Der Steinkohlenbergbau des preussischen Staates im Saare-Reviere: Reisebericht. By Friedrich Okorn. *Berg- und Hüttenmännisches Jahrbuch der K. k. montanistischen Hochschulen zu Leoben und Přibram*, 1907, *vol. lv., pages* 1-80, *with* 3 *figures in the text and* 1 *map.*

The Saarbrücken coal-basin fills up a depression which started somewhere about the end of the Lower Carboniferous Epoch, probably along an ancient line of disturbance, and, gradually sagging until about the end of Lower Rothliegende time, provided an area wherein the terrestrial and freshwater formations constituting the productive Coal-measures could be laid down. The general strike of these measures (which form a monoclinal fold) is from north-east to south-west, the dip is north-westerly, diminishing quickly westwards from 40° at the south-eastern margin to 5°. The occurrence of coal-seams has been proved over a distance of 56 miles, from the Potzberg in the Bavarian Palatinate, through St. Avold, Falkenberg, Bolchen, and Busendorf in Lorraine, and thence across the frontier into French territory. The breadth of the basin varies between 18 and 25 miles in the north-east, and attains 43½ miles in the south-west. On the south-east Archæan gneisses and granites appear to underlie the coal-basin, while on the north-west the Lower Devonian conglomerates, mottled slates, micaceous and quartzose sandstones and clay-slates, form the marginal rocks. At no point have the strata which immediately underlie the Coal-measures been exposed. The succession of the Saarbrücken Coal-measures, averaging a total thickness of 14,750 feet, is, in descending order, as follows:—

Upper Division, poor in coal-seams.	Upper Ottweiler Beds.—Grey, seldom red, shales, sandstones and conglomerates. Breitenbach or Hausbrand coal-seam.
	Middle Ottweiler Beds.—Red and grey sandstones and shales, also conglomerates and subordinate limestones. Hirtel seams.
	Lower Ottweiler Beds (*Leaia*-beds).—Greenish-grey and red shales and sandstones. Wohlschied and Lummerschied seams.
	Upper Saarbrücken Beds.—Generally red, occasionally grey shales and sandstones. At the base is the Holzer conglomerate.
Lower Division, rich in coal-seams.	Middle Saarbrücken Beds.—Dark-grey shales, grey to pale-grey sandstones and conglomerates. Claystone-bands. Upper and lower long-flame coal-groups.
	Lower Saarbrücken Beds.—(St. Ingbert Beds in part). Grey shales, sandstones, and conglomerates. "Basement coal-belt," or bituminous coal-group.

The seams usually consist of several bands of coal separated by barren partings, which rarely contain a thickness of pure coal exceeding 3¼ feet, and according to the fluctuating thickness of the partings are worked either as one seam or considered and worked as distinct seams. Among the thickest seams are the Huyssen seam of the Kohlwald colliery (16·3 feet, including 4 feet of partings); the Landsweiler seam of the Reden colliery (16·14 feet,

including 4½ feet of partings); and the Henry seam of the Klein Rosseln colliery (26¼ to 29½ feet, split up into twelve or sixteen bands, the thickness of pure coal ranging from 19½ to 21½ feet). The immediate roof of the seams is *brandschiefer* (bituminous slate), and the immediate floor always ordinary shale. The partings are usually *brandschiefer* shales, occasionally clay, ironstone or clay-stone; thick partings pass into sandstone. The uppermost of the seams hitherto worked in the Saare district is the Grenzkohlen (or Breitenbach or Hausbrand) seam, which has been traced from Dirmingen (in the north-eastern part of the field) through Mainzweiler to Breitenbach and Steinbach in the Palatinate, over a length of 18½ miles or more. The Hirtel seams, lying 1,300 feet deeper down, and proved over an extent of 10 miles from Labach to Illingen, consisting of an assemblage of narrow bands of impure coal (averaging a total thickness of 1¼ to 3 feet) have not (so far) repaid working. Some 1,300 feet below these comes the Schwalbach-Lummerschied seam, and 500 feet below this again the Wahlschied seam, which are the highest seams worked in the Prussian State collieries. Of far greater importance are the seams of the upper and lower long-flame coal-groups, the lie and composition of which have been proved along the strike for a distance of 30 miles within Prussian territory, and over a breadth of nearly 2 miles. The upper group at its maximum (Reden colliery) includes fifteen to twenty workable seams with a total thickness of 78¾ feet of coal; the lower group includes only two or three workable seams, with a total thickness of 11½ to 14¾ feet of coal. The measures intervening between the long-flame and the bituminous coal-groups contain a few seams, most of which are less than 12 inches thick; nevertheless, they are worked at some collieries, and are likely to be more extensively worked as the thicker seams approach the limit of exhaustion. The bituminous coal-group, including well over a hundred seams with a total thickness of 115 to 135 feet of coal, suitable some for coking, some for gas-manufacture, and some for boiler-firing purposes, is perhaps the most important division of the entire series. Below this comes the Rotheller group, worked only at the Bavarian Government colliery of St. Ingbert; it contains about 65½ feet of pure coal, distributed among 70 or 80 seams, few of which attain a thickness of 2¼ feet, the majority being less than 12 inches thick. The Coal-measures are much disturbed by faulting, the most considerable fault being that known as the Main Southern Fault, which indeed constitutes the southern boundary of the coalfield. The amount of coal in sight in the 265,000 acres reserved by the Prussian Government is estimated (down to a depth of 3,000 feet) at 3,660,362,000 metric tons; that in sight in concessions appertaining to Bavaria and Lorraine (both governmental and non-governmental) is estimated to amount to 156,880,000 tons. But no estimate can be formed in regard to the newly-discovered enormous extension of the coalfield in Lorraine. The duration of the coal-supply in the area reserved by the Prussian State is reckoned to extend to five hundred years from now.

There are twenty-four collieries at work, most of which are independent one of the other in regard to haulage, ventilation, and pumping. The districts assigned to each colliery have generally natural boundaries, in the shape of faults. The depth of the workings increases on the whole from south to north, in accordance with the dip of the measures; the deepest Government shaft at present is that of the Louisenthal colliery (2,240 feet). The total heights of the workings, from bottom-level to top, are conditioned by the same circumstances as those which determine the area to be worked, that is, largely by the lie and number of the seams, the total height being generally greater in the long-flame coal-group than in the richer bituminous coal-group. Three-

quarters of the material necessary for packing is got on the spot, and a very small amount is sent down from bank or "washed in" (*einspülung* method). The recently extended use of packing has greatly contributed to the diminution of accidents by falls of stone or coal in the Saare basin. The "washed-in" packing consists of broken-up clinkers, waste from the heapstead, and sand. About 75 fans of various types (22 Guibal, 22 Pelzer, 12 Kley, 6 Capell, etc.) are in use for ventilating the pits, the first-named being perhaps the oldest, while the very newest fans set up are four of the Pelzer type and three of the Rateau. The evolution of fire-damp in the Saare collieries appears to follow a regular course, and is more marked in the bituminous coal-groups than in the long-flame; it also increases with the depth from the surface. There is a dangerous amount of dust in the deeper collieries, especially in the Eischbach valley. Wolf benzine-lamps, with generally a single gauze, possess a practical monopoly in this coal-field; recently, the cylinders have been made of a specially hard glass by a Jena firm, and although this increases the cost of the lamp by 40 per cent., its life is prolonged by 83 per cent. Friction-igniters have come recently into extended use, and the lamps are locked magnetically, or are provided with the "twin-bolt" or "twin-rivet" lock. Pit-fires are now of rare occurrence. All colliery-officials and a suitable number of pitmen are trained in the use of rescue-apparatus, about seven permanent rescue-companies to the number of 200 men being organized. In 1905, the rescue-appliances available included 41 of the Dræger type, 28 of the Giersberg, 29 Walcher-Gärtner, 12 Neupert pneumatophores, 36 anti-smoke masks of various types, and 170 electric accumulator-lamps, also of various types.

A detailed description is given of the methods of haulage, pumping (the inflow of water in the Saare collieries is comparatively unimportant), steam-raising, air-compressing, etc. All the coal that is brought to bank, or nearly all of it, has to undergo mechanical sorting and washing before it is marketable: these processes are described at great length. About 20 per cent. of the output is converted into coke, the amount got from the undried coal (reckoned at 100) being 53 or 57, as compared with 65 or 70 per cent. in the case of the Westphalian bituminous coal. The coke as sold yields about 12 per cent. of ash. The various processes of coking, with and without bye-products, and the various types of oven in use are described. The total number of persons employed, above and below ground, averages 47,000; the daily hours of work from bank to bank do not, for the pitmen, exceed 8½ hours; and for persons employed at points where the average temperature exceeds 72° Fahr. the working day is limited to 6 hours. Wages, provident associations, teaching institutions, the conditions of housing, recreation, etc., are each briefly dealt with, and the memoir forms on the whole an excellent survey of the present-day conditions of one of the most important coal-fields in the German Empire. L.L.B.

IRON-ORE DEPOSITS OF WÜRTTEMBERG, GERMANY.

Die Eisenerzlagerstätten Württembergs und ihre Volkswirtschaftliche Bedeutung. By Robert Fluhr. *Zeitschrift für praktische Geologie*, 1908, *vol. xvi., pages* 1-23, *with* 11 *figures in the text.*

The author describes in the first place the hæmatites of Neuenbürg, Freudenstadt, Waldrennach, and Dennach. These belong to a system of thirty-eight lodes, with a gangue of heavy-spar bearing red and brown hæmatite, which occur in the Bunter Sandstones of Western Württemberg, over an area of some 16½ square miles. The brown hæmatite is the most abundant ore, with an average of 50 per cent. of metallic iron. Its structure is in some places fibrous, in others compact, and the compact variety contains more than 1 per cent. of manganese.

A lengthy description is then given of the pisolitic clay-ironstones which occur among the Lower Jurassic yellow sandstones around Aalen and Geislingen, in the Kocher and Fils valleys respectively. In the first-mentioned district about ten bands of ironstone have been proved, their combined thickness amounting to 15¼ feet; while in the Fils valley this amount apparently shrinks to, at most, 9 feet, though mining operations are at all events facilitated by the concentration of the ore into a single band instead of its being distributed among ten bands. The above-mentioned sandstones form the conspicuous capping of the *Opalinus*-clays, and are said, in their present condition, to be the outcome of a process of leaching by surface-waters: in this process, all the lime-constituents have disappeared, and so a lime-flux has to be supplied when the ores are being smelted—a not inconsiderable item of expenditure. The pisolitic ironstone consists of small rounded granules of extraordinarily equal size (not unlike very small shot) with a clay-cement; the best grade of ore is of a dark chestnut-brown, while the lower grades have a lighter tinge, drawing more towards copper-red. The specific gravity of the undried mineral is 2·68. Irregularly-shaped quartz-granules are intermingled with the pisolitic ore, occasionally in such numbers as to destroy the industrial value of those portions of the ore-body. Fissures in the ore-body, infilled or coated with calcite, or, as the case may be, with calc-sinter, are of frequent occurrence; and the miners find these fissures helpful in working out the masses of ore.

On the southern flank of the Swabian Alb, the Jurassic rocks are mantled over by widespread Tertiary deposits; in pockets and pipes which go down into the Jurassic rocks, pisolitic ores of Tertiary age were at one time actively worked. It may be gathered that, on the whole, iron-ore mining has reached a very low ebb in the kingdom of Württemberg, since the figures tabulated by the author put the total production for the year 1906 at 7,872 tons, the number of workpeople employed being only 41. As to the amount of ore still in sight, he states that accurate estimates can only be formed in regard to the Wasseralfingen-Aalen district (4,943,400,000 cubic feet estimated). Although deep-level mining would seem hopeless in the case of ores which nearer the outcrop have come to be considered as barely workable, it is pointed out that deeper down their mineralogical composition is likely to be more advantageous, inasmuch as the lime will not have been leached out of them; and, if ever there be a shortage in the world's supplies of iron-ore, many will be glad to have recourse to the great natural storehouse of that ore which lies beneath the surface in Württemberg.

Borings for coal in that region have been unsuccessful, and great improvements in the navigable rivers and canals are necessary in order to permit of the easy transport of coal in bulk with (conceivably in the future) return cargoes of iron. In 1907 there was but one ironworks producing pig-iron left in activity in the kingdom of Württemberg, employing 25 workpeople; on the other hand there are several important works turning out machinery, etc., which have their own foundries attached to them. L. L. B.

AGE OF THE SIEGERLAND IRON-ORES, GERMANY.

Beitrag zur Kenntniss vom Alter der Siegerländer Erzgänge. *By* H. Lotz. *Zeitschrift für praktische Geologie*, 1907, *vol. xv., pages* 251-253, *with* 1 *figure in the text.*

The Glaskopf mine at Briersdorf was opened up in two systems of highly-disturbed, thrust, and fissured lodes, the general effect of such disturbances being to intensify the economic disadvantages that attended mining operations

and finally to cause the abandonment thereof. The infilling of the lodes is typical for the Siegerland district: spathose iron-ore is accompanied by chalcopyrite (either in isolated crystals or intergrown in thick masses with the iron-ore); ordinary pyrite is of less frequent occurrence. Diabase, varying in colour from very dark-green to a dirty yellow, was first struck at the 574-foot level, and later on at various lower levels; it evidently forms a dyke, some 16½ to 33 feet broad, dipping 60 degrees westwards. It cuts the Vorsichter lode at an acute angle, and the effect of its intrusion is to metamorphose by contact the spathic iron-ore into magnetite over a certain distance to the north. This magnetite has yielded 54 per cent. of metallic iron, as compared with the 46 to 48 per cent. yielded by the ordinary spathic ore of the mine (when roasted). The contact-metamorphism is said to extend laterally for 23 to 26 feet. On the south, after getting through the diabase, the miners found the lode very full of quartz and practically unworkable.

The Siegerland metalliferous lodes are in part, if not all, of ancient origin, dating back at least to Devonian times. It may be noted that the earliest diabases known in the Rhenish slate-area are of Upper Devonian age, and here there is proof that the diabases have invaded and altered pre-existing lodes. It seems clear that the Siegerland lodes were originally mineralized with iron-ore, and that silicification and pyritization (with chalcopyrite and ordinary pyrite) are phenomena of later date, possibly contemporaneous with, or subsequent to, the diabasic intrusions. Some of the disturbances to which the metalliferous lodes have been subjected must be assigned to the great orographic plication which took place during the Carboniferous Period.

L. L. B.

IRON- AND MANGANESE-ORE DEPOSITS OF OBERROSBACH, GERMANY.

Über die Genesis der Eisen- und Manganerzvorkommen bei Oberrosbach im Taunus. By — Bodifée. *Zeitschrift für praktische Geologie*, 1907, *vol. xv., page* 309-316, *with* 6 *figures in the text.*

Among the iron- and manganese ore-deposits which have of late years attracted increasing attention in the Grand Duchy of Hesse, next to the famous occurrence of the Lindener Mark at Giessen, that of Oberrosbach ranks perhaps in geological interest and industrial importance below the south-eastern flank of the Taunus, past which locality the railway from Friedberg to Homburg vor-der-Höhe runs. Here are two deposits, barely a mile apart, one of which lying north of the village the author designates the "old deposit," and the other, south-west of the village, the "new." Both lie immediately at the base of the Taunus. The core of this range consists of the Lower Devonian, so-called "Taunus Quartzite," overlain near the margin by clay-slates of variable thickness, which are in turn succeeded conformably by the *Stringocephalus*-limestone. This limestone, several hundred yards thick, has a general dip of 40 degrees, and a north-to-south strike. These Devonian rocks have undergone much folding, followed by faulting.

The "old" deposit has at present no economic importance, as the workings have been abandoned for several years. It lies directly upon the *Stringocephalus*-limestone, which is vertical at that point; and it has a width of 1,300 to 1,650 feet (corresponding to that of the limestone), an easterly dip of about 5 degrees, and a north-and-south strike, parallel with that of the limestone. Its workable height averaged 50 to 65 feet, and in process of working it was noticed that the limestone at the foot-wall was invariably in the condition of dolomite and presented an extremely undulating surface. The iron-

and manganese-ores were chiefly concentrated in the hollows and "pockets" of this surface, and therefore the ore-body would be more correctly described as a series of "nests" than as a bedded deposit.

The "new" deposit has been worked for the last 4 years; it strikes north and south, and has an easterly dip averaging 45 degrees. A number of shafts have been sunk, to a maximum depth of 300 feet, and have shown that the ore-body varies in thickness between 50 and 100 feet. It has all the characteristics of a truly bedded deposit. The dolomitized limestone, the invariable carrier of the ore in the "old" and in all the other Hessian deposits, has not been struck in these shafts at any point, despite the most sedulous investigation: either it lies at a far greater depth, or it has swerved considerably south-eastwards—the latter supposition seems to be confirmed by certain trial-borings put down within the last few years. The limestone has indeed been encountered therein at a depth of 220 feet, and (precisely as in the case of the "old" deposit) proves to be overlain by a band of crumbly ore of variable thickness; while it gives evidence of dolomitization for some 13 to 16 feet, as compared with 65 to 90 feet in the neighbourhood of the "old" deposit. The "new" deposit is underlain by slates, which at the immediate footwall are much weathered and argillaceous, with a coloration ranging from pale pink to white. The junction between the barren clay and the ore-body, although of extreme irregularity, is always clearly discernible. In contradistinction to the "old" deposit, the main mass of the ore is fairly tough and highly manganiferous, while the crumbly ores play a secondary part and occur only at the very uppermost portions near the hanging-wall. The immediate hanging-wall consists of pink clays, 33 to 50 feet thick, very different in character from the footwall clay, but similar in every respect to the clays which occur at the hanging-wall of the "old" deposit: the junction between them and the ore-body, although extremely irregular, the barren portions projecting like tongues into the ore, is well marked. Fragments of ore are occasionally found dispersed in the clays, and frequently quartz-gravel more or less conglomerated. These hanging-wall clays are overlain by sands of various colours and degrees of purity, and these again by drifts.

The conflicting views advanced by those eminent geologists who have investigated these deposits are summarized, and the author then sets forth his own opinion (1) in regard to the "old" deposit, that it arises both from processes of metasomatosis and concentrative sedimentation; (2) in regard to the "new" deposit, that highly carbonated and metalliferous waters reached the surface, and then, partly owing to the action of atmospheric oxygen, and partly owing to the evaporation of carbon-dioxide, the carbonates of iron and manganese were simultaneously oxidized and precipitated. It is noticeable in the "new" deposit that the iron-ores are sharply marked off from those of manganese, owing doubtless to the divergence in capacity of the two metals for oxidation. The waters from which the ores were precipitated evidently came from below. L. L. B.

LOWER CARBONIFEROUS ON THE EASTERN BORDER OF THE UPPER SILESIAN COALFIELD.

Über neuere Aufschlüsse untercarbonischer Schichten am Ostrande des oberschlesischen Steinkohlenbeckens. By R. Michael. *Jahrbuch der Königlich Preussischen Geologischen Landesanstalt zu Berlin*, 1907, *vol. xxviii., pages* 183-201, *with* 4 *figures in the text.*

Across the frontier in Austrian Poland recently-made deep borings have proved the productive Coal-measures south of the Vistula at Brescze and

Stare-Stawy, south of Oswiecim, at Polanka Wielka, south-east of the last-mentioned town, and north of the Vistula at Libiaz. At Przeciszow, east of Oswiecim, the Coal-measures were struck at the depth of 1,327 feet from the surface, and continued down to the depth of 1,686 feet, a coal-seam about 2 feet thick being proved at the depth of 1,673 feet. North-east of Przeciszow, in the commune of Olszyny, on the northern bank of the Vistula, a deep boring is said to have proved various coal-seams at depths ranging from 660 to 1,312 feet, a seam exceeding 13 feet in thickness having been struck at the latter depth.

While the Galician Coal-measures as a whole may be correlated with the Upper Silesian synclinal group (none of the borings so far published having recorded the anticlinal seams in Galicia), the productive Coal-measures of Tenczynek must be assigned to the basement series of Upper Silesia, and in the neighbourhood of Krzeszowice a little farther east, the Carboniferous Limestone already makes its appearance. Nay, more, it is probable that the Tenczynek beds are even older than the Upper Silesian basement-measures from which they differ in lithological character; plant-remains are extraordinarily scarce, but animal-remains are somewhat more abundant. The reported occurrence of *Posidonia Becheri* does not affect the question, and the author states that compressed *Anthracosiæ* from the Tenczynek Coal-measure shales have been shown to him as specimens of *Posidonia Becheri*. He takes occasion to refute once again Prof. F. Frech's hypothesis of the upward range of *Posidonia Becheri* into the productive Coal-measures of Upper Silesia, pointing out that the small forms which are all the evidence that Prof. Frech produces cannot with any reasonable certainty be assigned to *Posidonia Becheri* at all. The Tenczynek measures yield, besides coal comparable with the Silesian black coal, a tough, feebly lustrous, dark-brown cannel-coal which has a conchoidal fracture, contains a high percentage of gas, and is very easily inflammable. Of the two exploration-levels driven at Tenczynek, the older and westernmost has proved nine coal-seams, ranging in thickness from 15 inches to over 4 feet. In the great Christina level 590 feet of Jurassic strata were passed through before reaching the Coal-measures, and, after passing through barren sandstones and shales with an anticline of Carboniferous Limestone, the productive measures were only reached when the adit had been driven for a length of 1,640 yards. The following four seams were proved: Andreas, $3\frac{1}{4}$ to $5\frac{1}{4}$ feet thick; Christina I., 32 inches; Christina II., 30 inches; and Adam, $4\frac{1}{4}$ feet thick. The seams here strike south-eastwards, but the productive Coal-measures which crop out in the neighbourhood of Zalas, south of Tenczynek, strike almost due north and south and dip westwards. Three borings were put down between these two localities, with the view of determining the sequence and lie of the strata; the discovery in them of undoubtedly Lower Carboniferous rocks makes it doubtful whether a general north-and-south strike of the Upper Carboniferous along the eastern margin of the Upper Silesian basin extends as far as the Vistula. Moreover, the anthracitic seams proved in Zalas No. 3 boring are of greater age than the Tenczynek seams, and are more nearly comparable with the seams proved in deep borings in Russian Poland, in the district to the east of Tarnowitz. The results of the borings tend also to limit the extent of the productive measures of Tenczynek to the tectonic depression or *graben* of Jaworzno and Trzebinia, and to indicate that the eastern boundary of the Silesian Coal-measures does not extend so far towards Cracow as was at one time believed.

L. L. B.

ARSENICAL ORE-DEPOSITS OF REICHENSTEIN, SILESIA.

Über die Arsenerzlagerstätten von Reichenstein. By O. Wienecke. *Zeitschrift für praktische Geologie*, 1907, *vol. xv., pages* 273-285.

The mineral-industry in this district, hard by the Austrian frontier, dates, according to documentary evidence, at least as far back as the year 1270, and appears to have reached its culminating point somewhere about the middle of the sixteenth century, more especially under the hegemony of the Fuggers. About the beginning of the eighteenth century, gold-mining, which here had fallen from its former high estate, gave way to arsenical ore-mining; but in 1895, improvements in the chlorination-process allowed once more of profitable extraction of the gold, and since that year the ores have been actively mined both for that metal and for arsenic.

Perhaps the most conspicuous rock of the district is the mica-schist, forming the north-eastern margin of a belt about $1\frac{1}{4}$ miles in breadth, and consisting mainly of quartz and dark-brown mica. When felspar is added to these constituents, the mica-schist passes into a variety of gneiss. It alone in the neighbourhood of Reichenstein appears to include the bands of dolomitic limestone and the arsenical ore-bodies which are intimately associated therewith. The limestones, of extremely variable thickness and composition, coincide generally in dip and in strike with the enclosing mica-schists. In places, the mica-schists are traversed by granitic dykes, frequently rich in tourmaline, and contain in the vicinity of these dykes red garnets and graphitic inclusions. Although the arsenical deposits extend to the foot of the Jauersberg within the contact-aureole of the granite, direct relationship between them and the granite cannot be postulated.

Westward of the mica-schists, hornblendites and syenites alternate with gneisses; despite their extreme variability from the petrographic point of view, they are manifestly derived all from the same source and are most probably of eruptive origin. No arsenical ores have been found among these rocks so far.

The deposit worked by the only mine at present in activity, the Reicher Trost (or "Rich Consolation") mine, is unsurpassed in productiveness and in magnitude by any of the known ore-deposits of the district. Oft-repeated attempts to re-open the ancient workings on other of these ore-bodies have so far met with failure, and yet along the Landeck high road a line of old heapsteads is observed on each side, for a distance of three-quarters of a mile above the Reicher Trost mine. The ore-body worked here follows on the whole conformably the bedding of the mica-schists, which strike from west-north-west to east-south-east. It would appear to pitch south-westwards at an angle of 30 to 40 degrees; between the first and the fourth deep level the extent of the deposit is about 460 feet; and from the fourth level there is a gradual pinching-out of the eastern portion of the deposit, until at the ninth level the ore-body can only be followed along the strike for a distance of 140 feet or so. It is possible that, in the roof of the ninth level, a fault throws a portion of the deposit down. The thickness of the deposit is extremely variable; about its middle portion, between the fifth and the seventh levels, it reaches a maximum of 100 feet. The deposit, as now seen, has been much changed from its original condition by tectonic phenomena.

At the contact with the ore-lenticle the mica-schist passes into a greyish-green, slightly arseniferous, extremely tough rock in which quartz predominates. The dolomitic limestone immediately associated with the ore-body is of granular texture and a pale-blue colour, occasionally exhibiting dark parallel stripes. It increases in thickness concurrently with the depth, and

at the sixth level measures about 65 feet. Other rocks associated with the deposit are described, such as the *Kammgebirge*, a greyish-green, finely fibrous or compact rock intimately "intergrown" with a pure diopside-rock; and the serpentine, predominant in depth, but also proved at higher levels: now, these are the real carriers of the arsenical ores, which, however, vary in character according to the rock that carries them. In the *Kammgebirge* the arsenical ores occur in finely acicular crystals, intimately intergrown with the associated contact-minerals, seldom forming vein-like stringers. In the serpentine they occur in amorphous masses, associated with more or less finely divided magnetite. The best qualities of these ferro-sulphidic ores, appropriate for immediate smelting, contain about 50 per cent. of pure arsenical ore: they form nests, which along their periphery pass into poorer ores. No general rules can be laid down as to the distribution of the rich ore, either according to strike or according to dip. For the *Kammgebirge* ores the chemical formula suggested is either $Fe_2 As_3$ (leucopyrite) or $Fe_5 As_8$; for the serpentine-ores, the formula found by Dr. C. Güttler is $Fe As_2$ (löllingite). In contrast with these the true arsenical pyrites, associated with the deposits, is of secondary importance and of no industrial consequence. Analytical investigation shows the leucopyrites of the Reicher Trost mine to contain 28·6 parts per million of gold, the löllingites 23·7 parts per million, and arsenical pyrites (from the fourth level) 34·8 parts per million; but the last-named from the Fürstenstollen (Prince's Adit) only contained 5·2 parts per million. Certain details of the chlorination-process of extraction here are kept secret. Since 1895, on an average about 90 pounds of gold (995 fine) have been extracted from the smelter-residues of the arsenical ores.

A description of the other, apparently now unworked, arsenical ore deposits of the district is followed by a detailed consideration of the various hypotheses advanced as to the genesis of the ores. Premising that they have not been found outside the contact-aureole of the Jauersberg granite, the author defines these ore-deposits as typical contact-deposits. It may be noted that the characteristic greenish-grey diopside-rocks, the frequent associates of contact-metamorphosed limestones, are a striking testimony to the probability of this hypothesis. Certain mineral-occurrences are also cited as additional witnesses. Moreover, the arsenical ores belong precisely to that group of metalliferous ores which almost invariably occurs in contact-deposits in the neighbourhood of a granitic intrusion.

The author sketches the formation of the Reichenstein ores as follows:— A deep-seated granitic massif sent out apatitic and pegmatitic apophyses into the surrounding mica-schists. The granitic "mother-liquors" whence emanated metal-laden gases and vapours especially rich in arsenic, bursting forth with enormous pressure at the time of the granitic intrusion, made their way up through fissures in the dolomitic limestone, altering partly the limestone into diopside and precipitating their metallic particles, a precipitation accelerated by the chemical reactions due to the limestone itself and to certain "mineralizers." (Genesis of the leucopyrites.)

At a later period, when the magma had given off some of its heat to the neighbouring rock-masses, thermal springs welled up through the old fissures, acting both on such of the dolomitic limestone as had so far escaped contact-metamorphism, and on the diopside-rock (in part), altering the magnesian calcium carbonates into serpentine, and liberating a certain amount of carbonate of lime. These thermal waters, at the same time, precipitated the metallic particles which they held in solution. (Genesis of the löllingites, magnetic and ordinary pyrites, and magnetite.) L. L. B.

AURIFEROUS DEPOSITS OF BRUSSON, PIEDMONT.

Osservazioni mineralogiche sui Giacimenti auriferi di Brusson (Valle di Aosta). *By* Luigi Colomba. *Atti della Reale Accademia delle Scienze di Torino*, 1907, *vol. xlii., pages* 904-922, *and* 1 *plate*.

Within recent years exploration-work has been directed to certain lodes of gold-bearing quartz at the localities of Arbaz and Fenillaz, in the valley of the Evançon in the vicinity of Brusson. Although operations have now been abandoned at Arbaz, they are being actively continued at Fenillaz. The author visited the locality in the summer of 1906, with the view of studying the origin of the auriferous deposits, and he now presents the first-fruits of his researches in the form of a mineralogical investigation of the gold and the quartz.

The gold is disseminated in the quartz which forms the infilling of the lodes; and, as may be commonly noted in primary auriferous deposits, it is more abundant high up than low down. In the lower portions of the lodes it is intimately associated with pyrite, and also (though very rarely) with galena and tetrahedrite; in the upper portions of the lodes the gold is in the free state, despite the presence of the other minerals already mentioned, and especially of the pyrite. Where the gold is associated with pyrite it occurs in the midst of that mineral in small dendrites and blobs, which are easily set free as the pyrite decomposes.

The form which the free gold in the upper portions of the lodes assumes depends apparently on the particular habit of the quartz. Thus, where the quartz is compact, the gold is disseminated within its mass in small spangles and "nests." Where, as is the case near the outcrop, the quartz tends to assume a macrocrystalline structure, at some points forming an inextricable tangle of crystals, the gold seems to coat them with a thin film and to interpose itself among them like a cementing-material. In a few cases, calcspar takes the place of quartz in the lodes, and the gold cuts across it in various directions in plates which have a distinctly crystalline structure. At the points of enrichment where there are small cavities in the quartz, the gold generally occurs therein in dendrites, or in crystalline filaments from the extremities of which depend well-defined, lustrous, miniature crystals.

A detailed crystallographic description is given of the dendrites and crystals of the precious metal, noting by the way that some of the latter are curiously distorted. The remainder of the paper consists of a highly elaborate investigation of the quartz-crystals. L. L. B.

GEOLOGY OF THE GROZNY OIL-FIELD, RUSSIA.

Das Naphtagebiet von Grosnyj. *By* K. Kalitzky. *Mémoires du Comité géologique de Russie, new series*, 1906, *No.* 24, *pages* 1-40, *and* 6 *plates*.

West-north-westwards from the town of Grozny in the Terek basin extends for some 14 or 15 miles a range of hills, the maximum elevation of which does not exceed 660 feet. This range is regarded by many Russian authors as a spur of the Sunzha massif; but Dr. Kalitzky points out that it is orographically isolated, being formed by an independent anticlinal fold. The crest of the anticline does not, however, coincide with the summit-line of the range, but is shifted towards the northern flank. Moreover, the crest of the anticline is contorted in the direction of the strike, with the result that the oldest beds crop out in the central portion of the range, but dip away thence qua-quaversally—the dip being steep to the northward and southward, gradual to the eastward and westward. The oil-belt is associated with the domal

region of the anticline, extending somewhat over into the southern limb. Prospectors now carefully avoid the northern limb with its steeply-dipping beds (40 to 90 degrees), even where the dip shows signs of diminution, as all the borings put down on the northern limb have yielded unfavourable results. Thanks to the boring operations which have been going on since 1893, the details of about 500 sections are available—unhappily, their topographical distribution is extremely irregular. Natural exposures, with a few isolated exceptions, are conspicuous by their absence; a mantle of drift-deposits covers the entire range to a depth of 5 or 6 feet, and bears in summer a luxuriant crop of tall grasses and other plants admirably sufficient to conceal old surface-excavations. Nevertheless, investigations conducted in the course of the year 1904 enable the author to give a detailed synopsis of the rock-succession. The entire series falls within the Miocene, and is, in descending order, as follows:—

		Feet.
Mæotic stage.—Akchagil Beds.	Limestones, limestone-conglomerates, calcareous sandstones and clayey sands, calcareous clays.	1,395
Break.		
Middle Sarmatic stage.	Grey shales, with occasional thin flaggy limestones ...	130 to 1,050
	Calcareous clays, with limestones in the upper portion of the group.	312
Lower Sarmatic stage.	Calcareous clays with intercalations of chalk-like marl ...	56
	Calcareous and shaly clays, with frequently interbanded limestones.	141
Passage-beds.	*Spaniodontella*-beds. Shaly and sandy clays, clayey limestones, calcareous clays and sandstones, pure sandstones (all sandstones water-bearing), and limestones.	164
	Chokrak Beds. Shaly and sandy clays, *petroleum-bearing* sandstones (clayey, calcareous, etc.) limestones (frequently nodular), dolomites.	1,214
Mediterranean stage.—*Spirialis*-beds.	Black shaly clays, limestones, black nodular limestones, dolomites.	?

The petroleum-bearing sandstones of the Chokrak group do not crop out at the surface in the area here surveyed; but the scientific value of the borehole-sections and borers' diaries, which are consequently the only available data, is generally of small account. The sections of even closely neighbouring boreholes are not mutually comparable, the cause lying partly with the extremely variable character of the Chokrak Beds, which present every gradation from pure clays, through sandy clays and clayey sandstones, to pure sandstones. The terminology customary in the Grozny oil-field is very misleading, as "clay with sand" is held to cover sandy clays, as well as pure clays with intercalations of pure sand, and even clayey sandstones. Limestones are not as a rule recorded in the borers' sections, although nearly every boring passes through numerous bands of limestone. All the boreholes, except those which reach at the very beginning the *Spaniodontella*-beds, pass through yellow clays (decomposition-products of the grey), then through grey clays, and finally into the dark (blackish-brown) clays, in which sandstones of variable thickness are struck. The upper sandstones are water-bearing, the lower carry the oil. The author assigns the reasons for which it is impossible to regard these Chokrak sandstones as the primary, original oil-carriers: how the petroleum came thither is not at present clear. Certainly it did not come by way of the faults mapped by the author in the central portion of the range, as, far from being conduits, they constituted great partition-walls cutting up the oil-field into distinct parcels of territory. West of a given

fault, for instance, the petroleum was so charged with gas as to well forth in a natural fountain; east thereof, the oil from the very beginning had to be pumped up. L. L. B.

PITKÄRANTA ORE-DEPOSITS, FINLAND.

Die Erzlagerstätten von Pitkäranta am Ladoga-See. By Otto Trüstedt. *Bulletin de la Commission géologique de Finlande*, 1907, *vol. iv., No.* 19, *pages* 1-333, *with* 80 *figures in the text*, 1 *map, and* 19 *plates.*

The preface to this monograph is followed by a bibliography of the subject comprising 130 entries and covering the years 1785 to 1907. About 35 pages are taken up with historical matter, recapitulating the first records of prospecting and exploration-work in the area in the early years of the nineteenth century, and retracing the ups and downs of the mineral-industry of Pitkäranta until its abandonment in 1904. Statistical tables of output are given from 1814 until that year. Although the author states that, at the time of writing, the greater part of the workings were under water, and that the sorting and smelting-houses, etc., were crumbling to ruin, he adds a footnote to the effect that in January, 1907, the entire property passed into the possession of a British syndicate, and that there was consequently reasonable hope of a revival of the mining industry of Pitkäranta.

The district here described embraces that part of the north-eastern coast of Lake Ladoga which belongs to Finland, and is bounded on the east by the great ellipsoidal massif of Rapakivi granite; it presents to the lake a very rugged and much indented coast-line, characterized by numerous skerries and islets. The rocks among which the ore-deposits occur are all of Archæan age, and predominantly early Archæan. Infolded among the pre-Ladogan granite-gneisses, and following all the variations in strike and dip thereof, the Ladogan mica-schists form an elongated basin trending north-westwards, surrounded by a series of smaller basins, to the whole of which the author applies the appellation of the "Pitkäranta syncline." Dioritic schists intrude in great dykes and stockworks into the pre-Ladogan granite-gneisses; between these and the Ladogan schists intervenes a belt of hornblende-schists, 330 to 1,000 feet thick, and at the contact of the hornblendic rocks, both with the pre-Ladogan at their base and with the Ladogan at their summit, occur more or less thick bands of crystalline (mostly dolomitic) limestone and lime-silicate-rock (*skarn*) derived from the last-named. There is a less constant horizon of limestone and *skarn*, some little way up in the hornblende-schists; and all three horizons are ore-carriers, at certain localities. The eruptives of post-Ladogan date (quartz-diorites, granites, pegmatites) cover but small areas in comparison on the one hand with the older rocks just enumerated, and on the other with the still later Rapakivi granite. A detailed description is given of all these, and the tectonic disturbances to which the district has been subjected, now expressed by folds and innumerable faults, are discussed.

From the point of view of the ore-deposits the area is roughly divisible into (1) the "old mining-field" of Pitkäranta, the almost exclusive receptacle of the copper and tin-ores of this region, and by far the most extensive mining-field; (2) the "new mining-field" of Pitkäranta; (3) the mining-field of Hopunvaara; and (4) the mining-field of Lupikko. About 60 pages are devoted to a detailed description of the ore-deposits of the lower zone in the "old mining-field," as proved in more than a score of different mines and workings. In order of abundance the following are the ores here obtained:—Magnetite, chalcopyrite, zinc-blende, cassiterite, pyrite, galena, redruthite, erubescite, magnetic pyrites, and molybdenite, the last-named being evidently the oldest

and possibly the only primary sulphide in these deposits. Native silver, copper, and bismuth are of rare occurrence therein, as also specular iron-ore, fahlore, galena, bismuthite, telluric bismuth, etc. The associated minerals are predominantly lime-magnesia silicates and in part ferruginous lime-alumina silicates, while magnesian silicates, such as serpentine, play a very subordinate part.

Only one deposit in the old mining-field, that of the Ristaus mine, occurs at the upper limestone-horizon; it was first discovered in 1897, by means of magnetometric observations. The deposit is an example of metasomatic replacement of limestone by serpentine intermixed with magnetite (the principal ore here), sulphides of copper and zinc, etc., and cassiterite. Scheelite also is abundantly represented at this mine; indeed, it is of very widespread occurrence throughout the "old mining-field," wherever metalliferous ores are found. The amount of ore-bearing rock in sight at the Ristaus mine, averaging 30 per cent. of metallic iron, is estimated at 150,000 metric tons.

The "new mining-field," a group of deposits extending for a mile and a half nearly due north and south along the eastern limb of the Pitkäranta fold, was practically unknown before the year 1894. Its geological structure is very similar to that of the old mining-field, but pegmatitic intrusions and faults appear to be of much less frequent occurrence. Calculating the mean depth of the ore-bodies at 400 feet or thereabouts (and this would appear to be a conservative estimate) there is a mass of some 4,000,000 tons of magnetic iron-ore available here, without reckoning the sulphides of other metals, such as copper and zinc.

It was only in 1895 that the modern development of geological and magnetometric research showed the long-known Hopunvaara field (the north-eastern extremity of the Pitkäranta syncline), by reason of its extraordinary wealth in magnetic iron-ore, to be one of the most important areas in the entire district. The detailed lithological and mineralogical description of the deposits and the discussion of their mode of formation occupy about 60 pages. The average depth of the ore-bodies being again taken as 400 feet, the amount of available ore averaging from 28 to 30 per cent. of metallic iron is estimated at about 5,000,000 metric tons.

Some 20 pages are devoted to the description of the Lupikko field, due south of that of Hopunvaara, and the amount of available magnetic ore at a similar depth, averaging 26 to 28 per cent. of metallic iron, is estimated at about 2½ million metric tons.

Analyses are tabulated (29 in number) of the magnetic iron-ores, and what few can be scraped together (10) of the copper- and zinc-ores; and in the concluding section of the memoir the various theories propounded as to the genesis of the Pitkäranta ores are reviewed at considerable length. The author claims to have proved that the *skarn* which forms the substratum of the ore-deposits was derived by contact-metamorphism from limestones similar to those preserved at certain localities in the upper limestone-belt. The alteration took place in early pre-Cambrian time, as a consequence of the post-Ladogan granitic and pegmatitic intrusions, and was in places characterized by comparatively unimportant ore-impregnations. The molybdenite and graphite found in the *skarn*, as also, in all probability, the magnetic pyrites sometimes abundantly interspersed among the schists of the district, date from that moribund phase of vulcanicity. Moreover, the occurrences at Ristaus, Lupikko, and most especially in the Hopunvaara field, show that the magnetite (the oldest industrially-important ore in the deposits) is younger than the limestones among which it lies; there is no doubt whatever as to its

epigenetic character, nor as to its having been derived from thermal waters carrying metalliferous particles in solution. The same statement holds good of the still later ores—the cassiterite, the sulphides of copper, lead, zinc, etc., and reasons are assigned for regarding the pneumatolytic or sublimation-hypothesis of their origin as untenable. A connexion can be traced between the genesis of the ores and the peripheral contact-metamorphism due to the intrusion of the Rapakivi granite. Finally, an alphabetical list is given of all the minerals discovered in the district described.

It is hardly possible in an abstract to do justice to this memoir, which, thanks to the elaboration of painstaking detail in the accumulation of facts, and to the wealth of illustration employed in presenting them, will long remain as the standard work on the subject. L. L. B.

THE MINING DISTRICT OF NEVIANSK, RUSSIA.

Description géologique du District Minier de Neviansk. *By* A. Krasnopolsky. *Mémoires du Comité géologique de Russie*, 1906, *new series*, *No.* 25, *pages* 1-106, *and* 1 *map.*

Although this district has long been famous in the annals of gold-mining in the Urals, the author is the first to publish a complete monograph on its geological features. The area is characterized by the enormous development therein of massive crystalline rocks, among which may be mentioned the granitic rocks (including true granites, aplites, pegmatites, gneisses, and biotitic and hornblendic gneissose granites) of widespread occurrence in the eastern and central portions; the augitic and hornblendic porphyrites; the quartz-porphyries, occasionally schistose; the gabbros, which occur principally in the northern and western portions; the serpentines, confined to the north-western and south-eastern portions; and finally, the epidotites and garnet-rocks, obviously of secondary origin, which are associated with all the known deposits of magnetic iron-ore along the Brodovaya river. Metamorphic schists have been observed between Neviansk and the Kunara river, and clearly-stratified "porphyritic" tuffs along the banks of the Tagil, Shurala, and other rivers. An outcrop of Carboniferous Limestone is mapped near Korely, while the Devonian limestones form a broad belt near Neviansk. The only other sedimentary rocks in the district are of post-Tertiary age, including vast deposits of peat, gold-bearing alluvia, yellowish-red lœss-like clays, and also the famous "black earth" (*chernozem*). The gold-bearing alluvia occur in a great number of localities; but auriferous lodes are associated with the porphyrites (near Ayatskoye); with the schists (in the neighbourhood of Neviansk); and with the granites (near Konevsky). Brown hæmatite occurs in irregular nests in the clay which infills the cavities at the surface of the Devonian limestone in the vicinity of Neviansk. The magnetic iron-ore deposits along the Brodovaya, already mentioned, occur in nests, lodes, and impregnations; and the ore-bearing epidosites and garnetites are traversed by steeply-dipping porphyrite-dykes. With the serpentines near Ayatskoye and Anatolskaya are associated chromite-deposits, and some traces of copper-ore in patches and venules have been observed among the magnetites at the sources of the Bielakovka. Topazes and beryls are found in the pegmatite-veins which traverse the gneissose granites near the Alabashka and Murzinka rivers; raspberry-coloured tourmaline is found in the coarse-grained granitic dykes traversing the serpentines in the neighbourhood of Shaitanskoye, Sarapulka, etc.; and amethysts occur in the white quartz-veins which seam the coarse-grained granite near the villages of Kaigorodskoye, Alabashka, etc.

L. L. B.

CUPRIFEROUS DEPOSITS OF BOR, SERVIA.

Zur Paragenesis der Kupfererze von Bor in Serbien. *By* F. Cornu *and* M. Lazarevič. *Zeitschrift für praktische Geologie*, 1908, *vol. xvi., pages* 153-155, *with* 1 *figure in the text.*

This locality is situated about 19 miles north-east of Zajechar, the chief town of the department of Timok, in Eastern Servia. From Zajechar a light railway runs for 50 miles down to Radujevac, a river-port on the Danube, 80 miles distant from Belgrade, the capital of the little kingdom. The copper-ore deposits of Bor are the richest hitherto discovered in Servia, and are associated with an andesitic eruptive mass, over 30 miles in length from north to south, and from 6¼ to 9½ miles in breadth. The fundamental rocks of the country are crystalline schists, overlain by Cretaceous sedimentaries, and broken into by numerous igneous intrusions of which the above-mentioned andesitic mass is the chief. According to Dr. D. J. Antula, the cupriferous lodes are arranged in five parallel series from north to south, the general strike being concordant with the direction of tectonic movement and with the trend of the great fissures through which the andesitic magma originally forced its way upwards. The andesite is variously hornblendic, biotitic, and pyroxenic. Near the outcrop, the sulphidic ores (occasionally containing from 110 to 310 grains of gold and from 124 to 154 grains of silver per metric ton) give place to malachite and azurite, associated with decomposed andesite. Twenty-six analyses of the sulphidic ore yielded from 8 to 25 per cent. of metallic copper.

The authors controvert some of Dr. Antula's mineralogical determinations, and they describe, apart from iron-pyrites, as the most abundant sulphidic ores in the deposit: (1) covellite (Cu S) in splendid dark-blue crystalline aggregates, exactly similar to the mineral of Butte in Montana, intergrown with, or forming venules in, the compact greyish-yellow pyrite; (2) enargite sulph-arsenide of copper) in iron-grey aggregates intimately associated with the covellite and pyrites, or encrusting druses within the last-named mineral. Among the oxidized ores they find pisanite (copper-iron vitriol), in greenish-blue to dark-blue fibrous aggregates, which on exposure to dry air are quickly encrusted with a yellowish-brown film of basic sulphate of iron. Native sulphur also occurs, coating the pyrite and in cavities in the andesite. The ores principally worked at Bor at the present moment are the above-described covellite, enargite, and pyrite; and it is pointed out that this rare type of enargite-lode deposit must be sought as far afield as America and the Philippine, Bor furnishing the first European example thereof. L. L. B.

IRON-ORE DEPOSITS OF NORTHERN SWEDEN.

Die nordschwedischen Eisenerzlagerstätten. *By* R. Bärtling. *Zeitschrift für praktische Geologie*, 1908, *vol. xvi., pages* 89-108, *with* 2 *figures in the text.*

Details are given, in the first place, of the arrangement concluded between the Swedish Government and the Luossavaara-Kiirunavaara, Gellivare, and Grängesberg-Oxelösund mining companies, which came into force on the first day of 1908.

Among other matters, this arrangement fixes precisely the maximum amount of ore which is to be exported for the next thirty years. The fourteen deposits which fall within the scope of this arrangement are described in the following order:—

Kiirunavaara, the most considerable ore-body in Northern Sweden, intimately associated from the geological point of view with that of Luossavaara,

was first discovered at the beginning of the eighteenth century; but mining operations on the present extensive scale only date from the year 1902. The enormous rapidity with which the mineral-industry has developed there, may be gauged from the statistics tabulated by the author, showing that already by the end of 1906, the total output of ore for the four years amounted to 5,184,230 metric tons. The Kiirunavaara chain of hills, built up almost entirely of iron-ore, range from north to south, reaching in their highest summit, the Statsrådet, an altitude of 2,456 feet above sea-level. The predominant ore is the so-called "black ore," a very minutely crystalline intermixture in variable proportions of magnetite or specular iron-ore and apatite. Quartz, mica, hornblende, talc, and calcspar are accessory minerals, rarely bulking, however, for more than 2 to 4 per cent. in the intermixture. The Kiirunavaara ore is characterized by its very high percentage of iron, and its variable percentage of phosphorus (ranging from 0·003 to 6·626). Eighteen complete analyses are tabulated, and mean results are also given of seventy-four analyses (iron and phosphorus only). According to the percentage of phosphorus, the ore is graded for the market in six qualities; the proportions of titanium and sulphur are too minute to be taken into account. The deposit at the outcrop covers an area of 70¾ acres, but borings and magnetic-compass observations have proved its extension both northwards and southwards. In fine, the total amount of ore available within the concessions of the Kiirunavaara-Luossavaara Company is estimated at 480,000,000 metric tons.

Luossavaara, as is well known, is a continuation of the deposit just described, from which it is separated only by the lake of Luossajärvi, and yields ore which is practically identical in every respect, except that the proportions of iron and phosphorus are less variable. Eleven complete analyses are tabulated.

The *Nokutusvaara* and *Syvajärvi* deposits, barely 2 miles farther to the north-north-east, were discovered in 1888. Besides "black ore," containing over 2¼ per cent. of phosphorus, specular iron-ore with smaller percentages of phosphorus occurs here. The ores are much seamed by veins of quartz and calcspar. On the whole, these two deposits are of small industrial importance.

At *Haukivaara*, near Kiruna railway-station, about a mile south-east of Luossavaara, red hæmatite occurs in elongated lenticles rarely attaining a thickness of 26 feet, among the "porphyry-schists." Under present circumstances this deposit is not worth working. Some 3 miles south of Kiirunavaara, diggings through the drift have revealed at *Rakkurijoki* a deposit of "black ore," resembling closely in appearance the Gellivare mineral, and containing 42·31 per cent. of metallic iron, 0·25 of phosphorus, and 0·21 of titanic oxide. This deposit is believed to be of some importance.

The *Tuollujärvi* deposit, 3 miles to the east of Luossavaara, first discovered in 1898, has been explored by means of eight borings. It consists of a system of small intersecting lodes infilled with magnetite, or with porphyry rich in magnetite and hornblende. Barely a mile to the south of the comparatively unimportant deposit just described, beyond the lake, lies the *Tuolluvaara* deposit, which is not one of the fourteen included in the arrangement entered into between the mining companies and the Swedish Government. It was discovered in 1897 by Dr. Hjalmar Lundbohm, and exhibits "black ore" with a more or less broad marginal zone of magnetite in the midst of syenite-porphyry. Analyses show the percentage of metallic iron to vary from 64·84 to 71·04, and that of phosphorus from 0·002 to 0·030; titanic oxide was determined in only one case, yielding then 0·53 per cent., and similarly there was but one determination of sulphur, to the amount of 0·04 per cent. The

deposit covers an area of 2½ to 3 acres, and the quantity of available ore, down to a depth of 165 feet or so, is estimated at 2,500,000 metric tons.

About 22 miles south-east of Kiruna railway-station is an important group of deposits, as yet unworked on account of the absence of railway-communication. That of *Mertainen* may be regarded as an "ore-breccia": irregular masses of magnetite are dispersed through a syenite-porphyry breccia, the fragments of which are abundantly cemented by magnetite with some hornblende, and the breccia passes gradually into syenite-porphyry with stringers and amygdules of magnetite, and finally into completely barren syenite-porphyry. The results of fifty-two analyses show the percentage of metallic iron to range from 41·28 to 69·94, and that of phosphorus from *nil* to 1·106 (though, on the whole, it barely averages 0·02). The area of workable ore covers 21 acres, but the geological conditions do not at present permit of an estimate of the probable quantity of ore in sight. The deposit of *Painirova*, south of that just described, is of very similar character, but of less importance. The *Svappavaara* deposit, another of those not included in the above-mentioned arrangement, was worked as long ago as the seventeenth century for its copper-ores: after many years of neglect and oblivion, attention was called to its wealth in iron-ore in 1875. "Black ore" and red hæmatite occur in huge lenticles among syenite-granulites: with these ores, which pass gradually one into the other, are associated apatite and calcspar. The percentage of metallic iron in the "black ore" ranges from 43·20 to 65·85, and that of phosphorus from 0·632 to 3·188. In the red hæmatite, the corresponding extreme variations are 48·12 to 70·09 per cent., and 0·033 to 1·260. The deposit covers an area of about 12½ acres; reckoning from the outcrop at the top of the hill down to the level of the projected railway (230 feet) there are 13,000,000 metric tons of ore in sight; but, if we reckon down to the level of the surrounding marshes (100 feet lower), the quantity of ore probably available is increased to 19,000,000 metric tons. Barely a mile and a quarter distant is the equally important deposit of *Leveniäniemi* (also outside the pact) proved by means of magnetometric measurements some ten years ago. Out of twenty-three borings, nineteen have struck ore below the drift, going in some cases through a thickness of 180 feet or more of pure iron-ore, without reaching the footwall of the ore-mass. The "black ore" and red hæmatite found here are of precisely similar character to those of Svappavaara.

Mining operations on the present extensive scale only date from 1892 at *Gellivare*. The "black ore" and red hæmatite, which here occur in huge lenticles and stockworks among gneisses seamed by granitic and pegmatitic dykes, are marketed in three grades, in inverse proportion to the percentage of phosphorus which they contain. A dozen analyses of samples taken in 1904 are tabulated, and the area covered by the entire ore-body is estimated at 45¾ acres. The quantity of ore still in sight in the fourteen mines now worked at Gellivare is estimated at over 41,300,000 metric tons; if to this be added the probable quantity available in the unworked portions of the field, the total will reach 59,000,000 tons. Close to the railway-line, midway between Gellivare and Kiruna station, is the quite unimportant deposit of *Lopasjärvi*.

The *Ekströmsberg* deposit, 18½ miles west-south-west of Kiirunavaara, consists of a great "bed" of black ore in quartz-porphyry, separated by country-rock with a few metalliferous lenticles from a smaller "bed" of red hæmatite. The general results of the analyses of about seventy samples may be stated as follows: metallic iron in the black ore, 64·10 per cent.; in the red hæmatite,

61·07; and in the smaller lenticles, 63·15. The respective percentages of phosphorus are 1·27, 1·46, and 1·094. The total area exceeds 12 acres, and the amount of ore in sight down to a depth of 460 feet is estimated at 30,000,000 metric tons. The mass can be worked opencast to a depth of 260 feet or more.

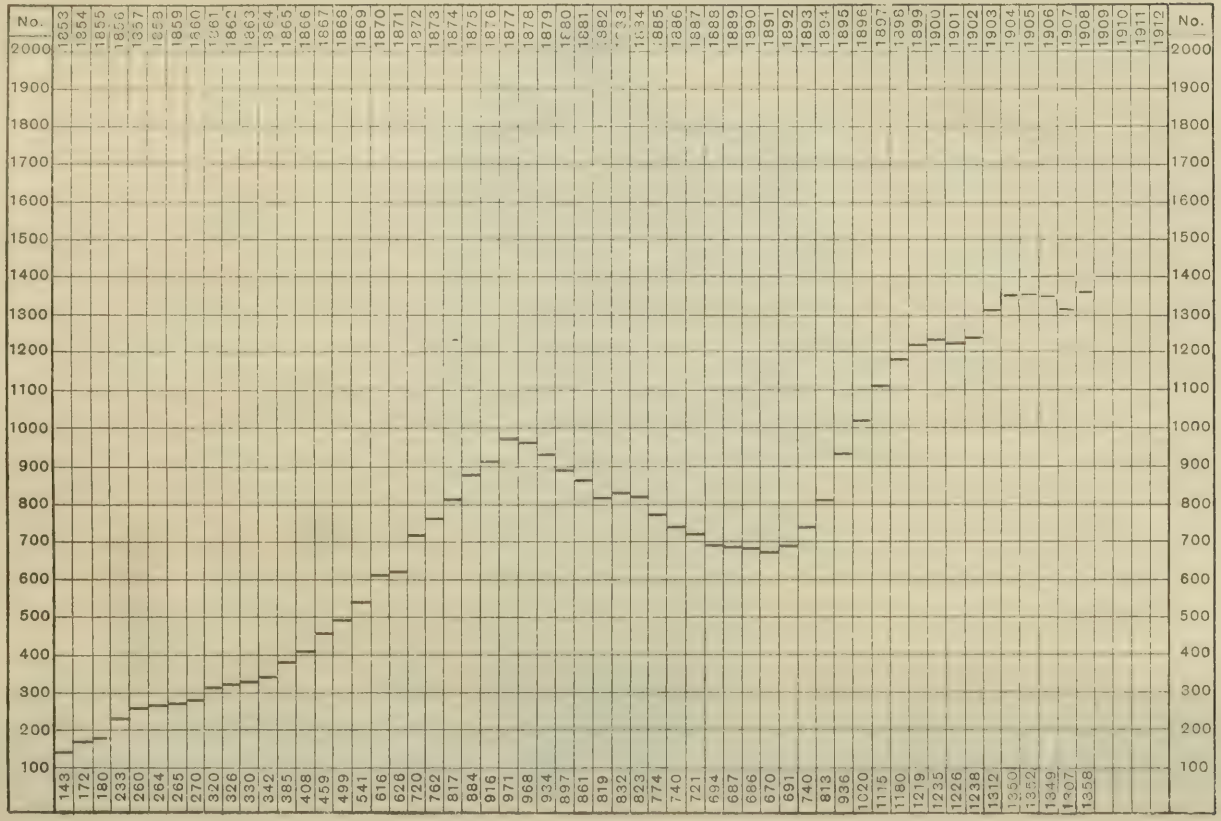
The deposits of *Laukujärvi* (3 miles north of that just described), *Toppi* or *Njuotjamaluspavaara*, and *Nakerivaara* do not come under the contract with the Swedish Government, and are not, apparently, of industrial importance.

Voluminous statistics are given of the output and consumption of iron-ore in the principal countries of the world, and more especially in Germany (including in the case of that country statistics of import and export); also of the output, export, and consumption in Sweden itself from 1897 to 1906; and it is shown that the German Empire is now Sweden's principal foreign customer for iron-ore. The before-mentioned contract with the Swedish Government limiting, as it would seem to do, the exports to fixed quantities during the next twenty years (with the probable intention of promoting the growth of the native metallurgical industries by retaining a certain proportion of ores for their use within the country), may in time cause German iron-founders and steel-manufacturers to look elsewhere for the needful supply of raw material.

L. L. B.

Wood Memorial Hall, and Offices of The North of England Institute of Mining and Mechanical Engineers, Newcastle-upon-Tyne.

Diagram exhibiting the Membership of The North of England Institute of Mining and Mechanical Engineers since its Foundation in 1852.



THE NORTH OF ENGLAND INSTITUTE

OF

Mining and Mechanical Engineers.

ANNUAL REPORT OF THE COUNCIL

AND

ACCOUNTS FOR THE YEAR 1907-1908;

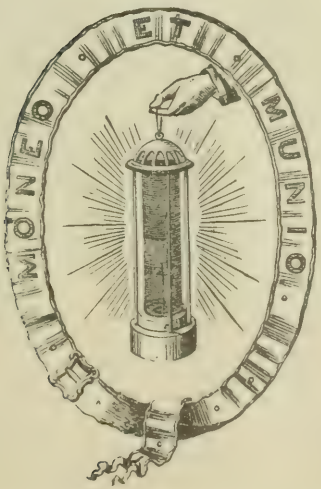
LIST OF

COUNCIL, OFFICERS AND MEMBERS

FOR THE YEAR 1908-1909;

THE CHARTER AND BYE-LAWS; Etc.

1907-1908.



NEWCASTLE-UPON-TYNE: PUBLISHED BY THE INSTITUTE.

Printed by Andrew Reid & Company, Limited, London and Newcastle-upon-Tyne.

1908.

CONTENTS.

	PAGE.
Annual Report of the Council, 1907-1908	v
Annual Report of the Finance Committee	x
General Statement, June 30th, 1908	xi
The Treasurer in Account with The North of England Institute of Mining and Mechanical Engineers for the Year ending June 30th, 1908 ...	xii
The Treasurer of The North of England Institute of Mining and Mechanical Engineers in Account with Subscriptions, 1907-1908	xiv
List of Committees appointed by the Council, 1908-1909	xvi
Officers, 1908-1909	xvii
Patrons	xviii
Honorary Members	xviii
Members	xix
Associate Members	xlvi
Associates	l
Students	lvi
Subscribers	lviii
Charter of The North of England Institute of Mining and Mechanical Engineers	lx
Bye-laws	lxiii
Appendix to the Bye-laws	lxix

THE NORTH OF ENGLAND INSTITUTE OF MINING MECHANICAL ENGINEERS.

ANNUAL REPORT OF THE COUNCIL, 1907-1908.

The Council regret to have to place on record the great loss that the Institute has sustained by the death of the Secretary, Mr. M. Walton Brown. Mr. Brown's connexion with the Institute dated back to the year 1871, when he was elected a student, his transference to the class of member taking place in the year 1878. He was elected a Member of Council in the year 1887, serving continuously thereon until the year 1891, when he was appointed the Secretary of the Institute. His connexion with the Institute was such a lengthy one, he had so complete a knowledge of its affairs in every detail, and he was always so ready to place his services and stores of information upon all subjects relating to mining at the disposal of the members, that his loss to the Institute is well nigh irreparable. An interesting memoir has been written by Mr. H. F. Bulman, and published in the *Transactions*.

The Council, after a careful consideration of the question of appointing a successor to Mr. Brown, decided that it would be to the interests of the Institute "That the Secretaryship be vested in an Honorary Secretary, for a period not exceeding two years, and that Mr. T. E. Forster be asked to accept the position." Mr. Forster expressed his willingness to act, but has now vacated the position, he having been nominated for the office of President for the ensuing year. Mr. John H. Merivale has accepted the Honorary Secretaryship, and the Institute will retain the services of Mr. Lawrence Austin as Secretary, Mr. Austin having assisted the late Mr. Brown and his predecessor for a period of twenty years. It is confidently hoped that these arrangements will conduce to the prosperity of the Institute.

The following table shows the progress of the membership during recent years :—

Year ending August 1st.	1902.	1905.	1908.
Honorary members	25	24	21
Members	893	953	942
Associate members	109	113	105
Associates	122	178	209
Students	66	56	48
Subscribers	23	28	33
Totals	1,238	1,352	1,358

The deaths (10) include the following: Members: Martin Walton Brown, Thomas Forster Brown, Edward Descou Chester, George Davey, Charles Ashley Shute, John Barret Squire and Henry Frederick Swan. Associate members: William Alder and John Ingledew Hopper. Associate: William Cockburn.

The resignations (31) include the following:—Members:

Charles Ernest Alger, Harry Foster Bain, Victor Manuel Braschi, Richard Henry Brown, Charles Crofton, Frederic James Edge, John Charles Forrest, Frederick William Grey, James Kenneth Guthrie, James Hay, Thomas James, Charles Warren Bowen Jenkins, John William Jobling, J. Dyer Lewis, Edward David Miles, Frank Reed, D. John Arthur Rees, Philip Rhinelander Robert, Robert Roberts, John G. Thompson, Jesse Wallwork and Alpheus Fuller Williams. Associate member: Arthur Cecil Broadbent. Associates: Bertram Atkinson, Christopher Elliott, William Henry Gidney, John Naisbit, Thomas Wakefield Parkin, John Urwin and Thomas Urwin. Subscriber: The Butterknowle Colliery Company, Limited.

The following gentlemen (22) have ceased to be members during the past year:- Members: Ormsby Gore Adams, Andrew Danks, John Milnes Favell, Arthur Payne Gallwey, John James, John Evan Jordan, James Alexander McFarlane, Thomas Robert Maddison, Thomas Parker, Henry Rees Powell, William Edward Rowlands, Thomas B. Shipley, Henry Blair Walker and Joseph R. Wilson. Associate members: Benjamin Atherton Hampson, Willows Hildred, Richard John Matchett and Albert Tunnington. Associates: Patrick Bruce Junor, Jun., Robert Kellett and John William Robinson. Student: Claud Alleyne Robinson.

The Library has been maintained in an efficient condition during the year; the additions, by donation, exchange and purchase, include 250 bound volumes and 17 pamphlets, reports, etc.; and the Library now contains about 11,550 volumes and 380 unbound pamphlets. A card-catalogue of the books, etc., contained in the Library renders them easily available for reference.

Members would render useful service to the profession by the presentation of books, reports, plans, etc., to the Institute, to be preserved in the Library, and thereby become available for reference.

The following portraits of past-presidents of the Institute have been presented during the year, and inserted in the panels in the Lecture Theatre:—The late Mr. Nicholas Wood, by Sir Lindsay Wood, Bart.; the late Mr. George Clementson Greenwell, by Mr. G. C. Greenwell; the late Mr. John Marley, by Mr. J. W. Marley and his brother; Mr. John Bell Simpson; Mr. George May; Mr. John George Weeks; and Mr. Thomas Walter Benson.

The Council are pleased to report that the gallery of portraits of past-presidents and secretaries is now complete, with the exception of Mr. Edward Sinclair, who was Honorary Secretary from 1852-1854, and whose portrait it has been found impossible to obtain. A suitable inscription has, however, been inserted in the panel. The formal handing over of the portraits to the Institute by Mr. T. E. Forster, on behalf of the donors, took place at the General Meeting of the members held upon June 20th, 1908, when they were accepted by the President, Mr. John H. Merivale, on behalf of the members.

The courses of lectures for colliery engineers, enginewrights, and apprentice mechanics have been continued at Armstrong College, Newcastle-upon-Tyne. The lectures are delivered on

Saturday afternoons, and the three years' course embraces the following subjects:—

1908-1909. Michaelmas Term, (1) Transmission of Power, and (2) Pumping and Ventilation. Epiphany Term, (3) Metallurgy of Iron and Steel, and (4) Mining Machinery (mainly machinery used underground).

1909-1910. Michaelmas Term, (5) Machine Drawing, and (6) the Chemistry of Fuel. Epiphany Term, (7) Strength of Materials (with experimental illustrations), and (8) Experimental Mechanics.

1910-1911. Michaelmas Term, (9) The Steam-engine, and (10) Theoretical Electricity. Epiphany Term, (11) Electrical Engineering, and (12) Haulage and Winding.

Several colliery-owners have paid the fees (£1 10s. per annum) and railway expenses of pupils attending the classes from their collieries. During the past year, the lectures of the Michaelmas Term on the Steam-engine were attended by 27 students, and Theoretical Electricity by 23 students, 27 of whom sat for examination and 17 passed; and during the Epiphany Term, the lectures on Electrical Engineering were attended by 23 students, and upon Haulage and Winding by 24 students; 22 of these were examined and 15 passed. The first prize for the Session 1907-1908, has been awarded to Mr. P. Bateson, who gained the highest aggregate number of marks; Messrs. A. Elliott and H. E. English dividing the second prize.

Supplementary volumes to *An Account of the Strata of Northumberland and Durham, as proved by Borings and Sinkings*, are in course of publication, a large number of sections having been received from members and other friends.

The Council have decided not to continue the compilation and publication of the "Subject-matter Index of Mining, Mechanical, and Metallurgical Literature."

Mr. Thomas Douglas continues to represent the Institute as a Governor of Armstrong College, and Mr. John H. Merivale, in conjunction with the President (Mr. T. E. Forster), represents the Institute on the Council of the College.

Mr. George May continues to represent the Institute upon the Board of Directors of the Institute and Coal Trade Chambers Company, Limited.

Mr. James Heppell Marr will represent the Institute at the Conference of the Corresponding Societies of the British Association for the Advancement of Science, to be held in Dublin, commencing on September 2nd, 1908. The Société de l'Industrie Minérale celebrated the Fiftieth Anniversary of its Foundation in June, 1908, and Mr. Arthur Morton Hedley represented the Institute thereat, and presented an Address.

The representatives of the Institute upon the Council of The Institution of Mining Engineers during the past year were as follows:—Messrs. William Armstrong, Bennett Hooper Brough, Charles Spearman Carnes, Arthur George Charleton, Frank Coulson, Benjamin Dodd, Thomas Douglas, John Henry Bacon Forster, John William Fryar, William Galloway, Thomas Young Greener, Samuel Hare, Arthur Morton Hedley, Philip Kirkup, Charles Catterall Leach, James McMurtrie, George May, John Herman Merivale, Charles Algernon Moreing, John Joseph Prest, Robert Foster Spence, Charles Herbert Steavenson, John George

Weeks, Richard Llewellyn Weeks and Arthur Nicholas Lindsay Wood.

G. C. Greenwell gold, silver and bronze medals may be awarded annually for approved papers "recording the results of experience of interest in mining, and especially where deductions and practical suggestions are made by the writer for the avoidance of accidents in mines."

A G. C. Greenwell gold medal has been awarded to Dr. P. Phillips Bedson for his "Experiments illustrative of the Inflammability of Mixtures of Coal-dust and Air."

Prizes for books have been awarded to the writers of the following papers, communicated to the members during the year 1906-1907 :—

* "Experiments illustrative of the Inflammability of Mixtures of Coal-dust and Air." By Dr. P. Phillips Bedson, D.Sc., Hon. M.I.M.E., and Mr. Henry Widdas, M.I.M.E.

"Treatment of Dust in Mines, Aboveground and Belowground." By Mr. Richard Harle, M.I.M.E.

"The Valuation of Mineral Properties." By Mr. Thomas Aloysius O'Donahue, M.I.M.E.

"Sinking through Magnesian Limestone and Yellow Sand by the Freezing-process at Dawdon Colliery, near Seaham Harbour, County Durham." By Mr. Ernest Seymour Wood, M.I.M.E.

* The prize for books is awarded to Mr. Widdas, Dr. Bedson having been awarded a G. C. Greenwell gold medal.

Under the will of the late Mr. John Daglish, funds have been placed at the disposal of Armstrong College for founding a Travelling Fellowship, to be called the "Daglish" Fellowship, candidates for which must be nominated by the Institute. Mr. Hugh Clarkson Annett was in January, 1908, awarded the Fellowship, and suitable arrangements for his gaining knowledge and experience in France were made, and similar arrangements will be made for a visit to Germany.

The rooms of the Institute have been used, during the year, by the Newcastle-upon-Tyne Association of Students of the Institution of Civil Engineers; the North of England Branch of the National Association of Colliery Managers; the North of England Gas Managers' Association; and The National Telephone Company, Limited.

Excursion meetings were held at Dunston-upon-Tyne on August 29th, 1907, when the members inspected the ferro-concrete constructions of the Co-operative Wholesale Society, Limited; at Felling on August 31st, 1907, when the members were present at the annual inspection of the Felling Colliery Corps (No. 6 District) of the St. John Ambulance Brigade, and also witnessed a demonstration of rescue-apparatus, and inspected the electric pumping-plant at Tyne Main colliery; and at South Bank on October 30th, 1907, when the members inspected the Cargo Fleet Steel- and Iron-works of the Cargo Fleet Iron Company, Limited.

In connexion with the demonstration of rescue-apparatus at Felling, an interesting exhibition of the various types of apparatus used was held in the Wood Memorial Hall.

The thanks of the Institute have been sent to the owners of the collieries, works, etc., visited during the year.

The papers printed in the *Transactions* during the year are as follows:—

"Demonstration of Rescue-apparatus, Felling, August 31st, 1907." By Mr. Lawrence Austin.
"Experiments illustrative of the Inflammability of Mixtures of Coal-dust and Air." Part II. By Dr. P. Phillips Bedson, D.Sc., Hon. M.I.M.E., and Mr. Henry Widdas, M.I.M.E.
"Memoir of Martin Walton Brown." By Mr. Harrison Francis Bulman, M.I.M.E.
"Wolf-Bohres Electric Safety-lamp." By Mr. Richard Cremer.
"The Occurrence and Commercial Uses of Fluorspar." By Mr. William Morley Egglestone.
"Flinty Chert, Hornstone, etc." By Mr. Thomas Harker.
"A Locking Hook for Sinking Purposes." By Prof. Henry Louis, M.I.M.E.
"On a Deficiency in the Nomenclature of Mineral Deposits." By Prof. Henry Louis, M.I.M.E.
"Presidential Address." By Mr. John Herman Merivale, M.I.M.E.
"The Strength of Cast-iron Tubbing for Deep Shafts." By Dr. John Morrow.
"Circulation and Heat Absorption in Steam Boilers." By Mr. Arthur Ross.
"Notes on Mining and Engineering in America and Canada." By Mr. Walter Rowley, M.I.M.E.
"A Simple Method of Water-stowage employed at No. 5 Pit of the Escarpelle Mines." By Mr. Sainte-Claire-Deville.
"Ferro-concrete work at Dunston-upon-Tyne."
"Electric Pump at Tyne Main Colliery."
"Cargo Fleet Steel- and Iron-works."

The Council in reporting last year that the North-eastern Railway Company had granted reduced railway-fares to members attending general or excursion meetings of the Institute, expressed the hope that the concession would lead to an increased attendance at the meetings. They regret that no material increase has resulted, but trust that in the future a larger number of members will avail themselves of the privilege.

The Institution of Mining Engineers has now entered upon its twentieth year, and the members are to be congratulated upon its continued success, and the increasing membership of the associated institutions. Meetings of the members were held in Sheffield in September, 1907, and in London in June, 1908, the attendance in each case being satisfactory.

Since the death of Mr. Martin Walton Brown, who was also Secretary of The Institution of Mining Engineers, Mr. Percy Strzelecki has acted as Secretary *pro tem.*, he having been an official of the Institution for the past seventeen years.

During the past year Mr. Thomas Douglas and the President (Mr. John Herman Merivale) have represented the Institute upon the Status and Qualifications of Membership Committee, and Mr. John George Weeks and the President (Mr. John Herman Merivale) upon the Secretaryship, Headquarters, and Status and Qualifications of Membership Committee of The Institution of Mining Engineers. As a result of the deliberations of these Committees, it has been decided that the Secretaryship of The Institution of Mining Engineers shall, in future, not be held by the Secretary of any one of the Federated Institutes, and that the headquarters of the Institution shall be removed to London. This will naturally result in increased working costs, which will be met for the first three years by the several Federated Institutes contributing to a guarantee fund *pro rata* to their membership.

ANNUAL REPORT OF THE FINANCE COMMITTEE.

The Finance Committee submit herewith a statement of accounts for the twelve months ending June 30th, 1908, duly audited.

The total receipts were £2,867 2s. Of this amount, £21 was paid as a life-composition in lieu of annual subscriptions, and £40 14s. as subscriptions paid in advance, leaving £2,805 8s. as the ordinary income of the year, compared with £2,928 1s. 3d. in the previous year. The amount received for ordinary current-year subscriptions was £2,218 10s., and arrears £239 18s., as against £2,264 17s. and £318 9s. respectively in the year 1906-1907. *Transactions* sold realized £11 5s. 8d., as compared with £19 3s. 9d. in the earlier period; the sum received for interest on investments was £335 14s. 4d., the amount in the former year being £325 11s. 6d.

The expenditure was £2,627 2s. 3d., that for the previous year being £2,622 13s. 3d. Referring to the items making up the total, the sum of £521 17s. 3d. was paid within the year for salaries and wages, as compared with £531 6s. 6d. during the previous year; this reduction is in consequence of the interval during which there has been no paid Secretary, and would have been larger but for the engagement of temporary assistance in the compilation of the Library Catalogue and the Subject-matter Index of Mining, Mechanical, and Metallurgical Literature. In the year 1906-1907 special expenditure was incurred in connexion with the visit of the American Institute of Mining Engineers and the experiments on coal-dust conducted at Armstrong College. The only special expenditure this year is for the cost of printing the volume of the Subject-matter Index of Mining, Mechanical and Metallurgical Literature for the year 1902. Increased expenditure is shown for printing circulars and advance copies of papers, furniture and repairs, heating and lighting, postages, and in the payments to The Institution of Mining Engineers.

The figures cited above show that the income exceeded the expenditure by £239 19s. 9d., and adding to this the balance of £752 9s., brought forward from the previous year, a total balance of £992 8s. 9d. remains to the credit of the Institute. Of this amount, £487 13s. 6d. has been invested in the purchase of stock of the Newcastle and Gateshead Gas Company, leaving the sum of £504 15s. 3d. to carry forward.

The names of 28 persons have been struck off the membership list in consequence of non-payment of subscriptions. The amount of subscriptions written off was £227 5s., of which £74 14s. was for sums due for the year 1907-1908, and £152 11s. for arrears. It is probable that a considerable proportion of these amounts will be recovered and credited in future years. Of the amounts previously written off, £59 19s. was recovered during the past year.

JOHN H. MERIVALE, *President.*

August 1st, 1908.

LIABILITIES.	£	s.	d.	£	s.	d.
Subscriptions paid in advance during the current year				40	14	0
The Institution of Mining Engineers				18	1	7
The George Clementson Greenwell prize fund	100	0	0			
Less, paid for medals	70	1	4			
				29	18	8
Printing, etc.				12	0	6
Capital				12,643	9	3
				£12,744	4	0

We, having examined the above account with the books, vouchers and securities relating thereto, certify that, in our opinion, it is correct. We have accepted the assets, books, pictures, maps, etc., and *Transactions* and other publications as valued by your officials.

JOHN G. BENSON AND SONS,
CHARTERED ACCOUNTANTS.

Newcastle-upon-Tyne,
July 30th, 1908.

ASSETS.	£	s.	d.	£	s.	d.
Balance of account at bankers	424	16	4			
,, in Treasurer's hands	77	12	3			
Outstanding accounts due from authors for excerpts	2	6	8			
				504	15	3
Arrears of subscriptions				280	6	0
179 shares in the Institute and Coal-trade Chambers Company, Limited (at cost)	4,100	0	0			
Institute and Coal-trade Chambers Company, Limited (mortgage)	1,400	0	0			
£340 consolidated 5 per cent. preference stock of the Newcastle and Gateshead Water Company (at cost)	499	17	6			
£450 ordinary stock of the Newcastle and Gateshead Gas Company (at cost)	487	13	6			
				6,487	11	0
(Of the above amount, £1,659 is due to life-subscriptions account.)						
Value of *Transactions* and other publications, as per stock account	321	11	9			
Books, pictures, maps, furniture and fittings	5,150	0	0			
				5,471	11	9
				£12,744	4	0

DR. THE TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND FOR THE YEAR ENDING

June 30th, 1907.	£	s.	d.	£	s.	d.
To balance of account at bankers	711	4	7			
„ „ in Treasurer's hands	38	5	11			
„ outstanding accounts due from authors for excerpts	2	18	6			
				752	9	0
June 30th, 1908.						
To dividend of 7½ per cent. on 179 shares of £20 each in the Institute and Coal-trade Chambers Company, Limited, for the year ending June 30th, 1908 ...	268	10	0			
„ interest on mortgage of £1,400 with the Institute and Coal-trade Chambers Company, Limited	47	15	6			
„ dividend on £340 consolidated 5 per cent. preference stock of the Newcastle and Gateshead Water Company	16	3	0			
„ dividend on £450 ordinary stock of the Newcastle and Gateshead Gas Company	3	5	10			
				335	14	4
To sales of *Transactions*				11	5	8
To SUBSCRIPTIONS FOR 1907-1908 AS FOLLOWS :—						
726 members ... ... @ £2 2s.	1,524	12	0			
84 associate members ... ... @ £2 2s.	176	8	0			
160 associates ... ... @ £1 5s.	200	0	0			
41 students ... ... @ £1 5s.	51	5	0			
63 new members ... ... @ £2 2s.	132	6	0			
6 new associate members ... ... @ £2 2s.	12	12	0			
30 new associates ... ... @ £1 5s.	37	10	0			
18 new students ... ... @ £1 5s.	22	10	0			
	2,157	3	0			
32 subscribing firms	115	10	0			
	2,272	13	0			
1 member, paid a life-composition	21	0	0			
	2,293	13	0			
Less, subscriptions for current year paid in advance at end of last year	54	3	0			
	2,239	10	0			
Add, arrears received	239	18	0			
	2,479	8	0			
Add, subscriptions paid in advance during current year	40	14	0			
				2,520	2	0
				£3,619	11	0

INSTITUTE OF MINING AND MECHANICAL ENGINEERS Cr.
JUNE 30TH, 1908.

June 30th, 1908.	£	s.	d.	£	s.	d.
By *Annual Report*	41	6	0			
„ bankers' charges	21	11	4			
„ circulars and advance copies of papers	83	8	8			
„ cleaning Wood Memorial Hall, offices, etc.	35	5	2			
„ electric light	36	10	9			
„ expenses of meetings	2	18	1			
„ fuel	29	12	2			
„ furniture and repairs	51	13	3			
„ George Clementson Greenwell prize fund: medals	2	13	0			
„ incidental expenses	2	12	1			
„ insurance	13	5	9			
„ investments	487	13	6			
„ lecture theatre	10	10	0			
„ library: binding £62 12 10						
„ „ books 12 8 8						
	75	1	6			
„ petty cash	2	1	1			
„ portraits of presidents	35	9	0			
„ postages: circulars £34 13 3½						
„ „ correspondence 16 13 9						
„ „ publications 41 10 8½						
	92	17	9			
„ prizes for papers	18	18	0			
„ rates and taxes	6	12	5			
„ rent of offices	24	8	0			
„ reporting of general meetings	12	12	0			
„ salaries, wages, auditing, etc.	521	17	3			
„ stationery, etc.	20	10	4			
„ *Subject-matter Index of Mining, Mechanical and Metallurgical Literature*	68	13	6			
„ translations of papers	1	15	0			
„ travelling expenses	12	1	3			
„ water rate	2	18	8			
„ Wood Memorial Hall	10	10	0			
				1,725	5	6
By The Institution of Mining Engineers	1,394	2	11			
Less, amounts paid by authors for excerpts	4	12	8			
				1,389	10	3
				3,114	15	9
By balance of account at bankers	124	16	4			
„ „ in Treasurer's hands	77	12	3			
„ outstanding accounts due from authors for excerpts	2	6	8			
				504	15	3
				£3,619	11	0

DR. THE TREASURER OF THE NORTH OF ENGLAND INSTITUTE OF MINING

		£ s. d.	£ s. d.	£ s. d.
To 903 members,				
51 of whom have paid life-compositions.				
852				
5 not included in printed list.				
857	@ £2 2s.	1,799 14 0		
1 paid a life-composition		21 0 0		
			1,820 14 0	
To 108 associate members.				
9 of whom have paid life-compositions				
99	@ £2 2s. ...		207 18 0	
To 194 associates,				
1 of whom has paid a life-composition.				
193				
6 paid as members.				
187	@ £1 5s.		233 15 0	
To 47 students,				
1 paid as a member.				
46	@ £1 5s.		57 10 0	
To 34 subscribing firms			119 14 0	2,439 11 0
To 63 new members	@ £2 2s.		132 6 0	
To 6 new associate members	@ £2 2s.		12 12 0	
To 30 new associates	@ £1 5s.		37 10 0	
To 18 new students	@ £1 5s.		22 10 0	204 18 0
To arrears, as per balance sheet, 1906-1907			336 14 0	
Add, arrears considered irrecoverable, but since paid ...			59 19 0	396 13 0
				3,041 2 0
To subscriptions paid in advance			... ...	40 14 0
				£3,081 16 0

AND MECHANICAL ENGINEERS IN ACCOUNT WITH SUBSCRIPTIONS, 1907-1908. CR.

		PAID. £ s. d.	UNPAID. £ s. d.	STRUCK OFF LIST. £ s. d.
By 726 members, paid	@ £2 2s.	1,524 12 0	.....	.....
104 „ unpaid ...	@ £2 2s.	.....	218 8 0	.....
4 „ excused payment	@ £2 2s.	.....	.....	8 8 0
3 „ dead	@ £2 2s.	.....	.....	6 6 0
20 „ struck off list	@ £2 2s.	.....	.....	42 0 0
857				
1 „ paid a life-composition		21 0 0	.....	.....
By 84 associate members, paid	@ £2 2s.	176 8 0	.....	.....
11 „ „ unpaid	@ £2 2s.	.....	23 2 0	.....
4 „ „ struck off list	@ £2 2s.	.....	.....	8 8 0
99				
By 160 associates, paid	@ £1 5s.	200 0 0	.....	.....
22 „ unpaid ...	@ £1 5s.	.....	27 10 0	.....
1 „ excused payment	@ £1 5s.	.....	.....	1 5 0
1 „ dead ..	@ £1 5s.	.....	.....	1 5 0
3 „ struck off list	@ £1 5s.	.....	.....	3 15 0
187				
By 41 students, paid	@ £1 5s.	51 5 0	.....	.....
4 „ unpaid ...	@ £1 5s.	.....	5 0 0	.....
1 „ struck off list...	@ £1 5s.	.....	.....	1 5 0
46				
By 32 subscribing firms, paid		115 10 0	.....	.....
1 „ „ unpaid		...	2 2 0	.....
1 „ „ excused payment ..		...	.....	2 2 0
34				
By 63 new members, paid ...	@ £2 2s.	132 6 0	.....	.....
By 6 new associate members, paid	@ £2 2s.	12 12 0	.....	.....
By 30 new associates, paid ...	@ £1 5s.	37 10 0	.....	.....
By 18 new students, paid ...	@ £1 5s.	22 10 0	.....	.....
		2,293 13 0	276 2 0	74 14 0
By arrears		239 18 0	4 4 0	152 11 0
		2,533 11 0		
By subscriptions paid in advance		40 14 0	.....	.....
		2,574 5 0	280 6 0	227 5 0
				280 6 0
				2,574 5 0
				£3,081 16 0

LIST OF COMMITTEES APPOINTED BY THE COUNCIL, 1908-1909.

Finance Committee.

Mr. Frank Coulson.
Mr. T. Douglas.
Mr. T. Y. Greener.
Mr. T. E. Jobling.
Mr. George May.
Mr. John Simpson.
Mr. J. B. Simpson.
Mr. J. G. Weeks.

Arrears Committee.

Mr. Frank Coulson.
Mr. T. Douglas.
Mr. T. Y. Greener.
Mr. T. E. Jobling.
Mr. George May.
Mr. John Simpson.
Mr. J. B. Simpson.
Mr. J. G. Weeks.

Library Committee.

Mr. R. S. Anderson.
Mr. Sidney Bates.
Mr. R. W. Berkley.
Mr. J. H. B. Forster.
Mr. J. P. Kirkup.
Mr. George May.
Mr. H. Palmer.
Mr. John Simpson.
Mr. J. G. Weeks.

Prizes Committee.

Mr. Austin Kirkup.
Mr. C. C. Leach.
Prof. H. Louis.
Mr. A. D. Nicholson.
Mr. H. Palmer.
Mr. John Simpson.

Borings and Sinkings Committee.

Mr. J. B. Atkinson.
Mr. R. Donald Bain.
Mr. W. C. Blackett.
Mr. Frank Coulson.
Mr. T. E. Forster.
Prof. G. A. L. Lebour.
Prof. H. Louis.
Mr. A. D. Nicholson.
Mr. R. F. Spence.

Reference Committee for Papers to Read.

(a) Coal-mining.

Mr. R. W. Berkley.
Mr. W. C. Blackett.
Mr. C. S. Carnes.
Mr. Benjamin Dodd.
Mr. A. M. Hedley.
Mr. C. C. Leach.
Prof. H. Louis.
Mr. George May.
Mr. J. H. Merivale.
Mr. H. Palmer.
Mr. John Simpson.
Mr. A. L. Steavenson.

(b) Metalliferous Mining.

Mr. R. Donald Bain.
Mr. A. M. Hedley.
Prof. H. Louis.
Mr. J. H. Merivale.
Mr. A. D. Nicholson.
Mr. A. L. Steavenson.
Mr. C. H. Steavenson.

(c) Geological.

Mr. R. S. Anderson.
Mr. R. Donald Bain.
Mr. Samuel Hare.
Mr. T. E. Jobling.
Prof. G. A. L. Lebour.
Mr. J. H. Merivale.
Mr. John Simpson.

(d) Mechanical and Electrical Engineering.

Mr. Sidney Bates.
Mr. W. C. Blackett.
Mr. Austin Kirkup.
Mr. J. P. Kirkup.
Mr. H. Lawrence.
Mr. C. C. Leach.
Mr. J. H. Merivale.
Mr. John Morison.
Mr. W. C. Mountain.
Mr. J. H. Nicholson.
Hon. C. A. Parsons.
Mr. A. L. Steavenson.

(e) Civil Engineering.

Mr. Benjamin Dodd.
Mr. J. H. B. Forster.
Mr. T. E. Forster.
Mr. W. C. Mountain.
Mr. M. W. Parrington.
Mr. J. B. Simpson.
Mr. A. L. Steavenson.

(f) Chemical.

Prof. P. Phillips Bedson.
Mr. R. W. Berkley.
Mr. Benjamin Dodd.
Dr. G. P. Lishman.

N.B.—The President is *ex-officio* on all Committees.

OFFICERS, 1908-1909.

PAST-PRESIDENTS (*ex-officio*).

Sir LINDSAY WOOD, Bart., The Hermitage, Chester-le-Street.
Mr. JOHN BELL SIMPSON, Bradley Hall, Wylam, S.O., Northumberland.
Mr. ADDISON LANGHORNE STEAVENSON, Durham.
Mr. THOMAS DOUGLAS, The Garth, Darlington.
Mr. GEORGE MAY, Clervaux Castle, Croft, Darlington.
Mr. WILLIAM ARMSTRONG, Wingate, S.O., County Durham.
Mr. JOHN GEORGE WEEKS, Bedlington, S.O., Northumberland.
Mr. WILLIAM OUTTERSON WOOD, South Hetton, S.O., County Durham.
Mr. THOMAS WALTER BENSON, Collingwood Buildings, Collingwood Street, Newcastle-upon-Tyne.
Mr. JOHN HERMAN MERIVALE, Togston Hall, Acklington, S.O., Northumberland.

PRESIDENT.

Mr. THOMAS EMERSON FORSTER, 3, Eldon Square, Newcastle-upon-Tyne.

VICE-PRESIDENTS.

Mr. JOHN BOLAND ATKINSON, H.M. Inspector of Mines, 2, Devonshire Terrace, Newcastle-upon-Tyne.
Mr. RICHARD DONALD BAIN, H.M. Inspector of Mines, Durham.
Mr. WILLIAM CUTHBERT BLACKETT, Acorn Close, Sacriston, Durham.
Mr. THOMAS YOUNG GREENER, West Lodge, Crook, S.O., County Durham.
Mr. MATTHEW WILLIAM PARRINGTON, Wearmouth Colliery, Sunderland.
Mr. JOHN SIMPSON, Heworth Colliery, Felling, S.O., County Durham.

RETIRING VICE-PRESIDENTS (*ex-officio*).

Mr. FRANK COULSON, Shamrock House, Durham.
Mr. THOMAS EMERSON FORSTER, 3, Eldon Square, Newcastle-upon-Tyne.
Mr. HENRY PALMER, Medomsley, S.O., County Durham.

COUNCILLORS.

Mr. ROBERT SIMPSON ANDERSON, Benwell View, Bentinck Road, Newcastle-upon-Tyne.
Mr. SIDNEY BATES, The Grange, Prudhoe, Ovingham, S.O., Northumberland.
Mr. RICHARD WILLIAM BERKLEY, Marley Hill, Swalwell, S.O., County Durham.
Mr. BENJAMIN DODD, Bearpark Colliery, Durham.
Mr. JOHN HENRY BACON FORSTER, Whitworth House, Spennymoor.
Mr. ARTHUR MORTON HEDLEY, Blaydon Burn, Blaydon-upon-Tyne, S.O., County Durham.
Mr. THOMAS EDGAR JOBLING, Bebside, S.O., Northumberland.
Mr. AUSTIN KIRKUP, Manor House, Penshaw, Fence Houses.
Mr. JOHN PHILIP KIRKUP, Burnhope, Durham.
Mr. PHILIP KIRKUP, Leafield House, Birtley, S.O., County Durham.
Mr. HENRY LAWRENCE, 13, Devonshire Place, Newcastle-upon-Tyne.
Mr. CHARLES CATTERALL LEACH, Seghill Colliery, Seghill, Dudley, S.O., Northumberland.
Mr. HENRY LOUIS, 4, Osborne Terrace, Newcastle-upon-Tyne.
Mr. JOHN MORISON, 14, Saville Row, Newcastle-upon-Tyne.
Mr. WILLIAM CHARLES MOUNTAIN, The Hermitage, Gateshead-upon-Tyne.
Mr. ARTHUR DARLING NICHOLSON, H.M. Inspector of Mines, 2, Graingerville, Newcastle-upon-Tyne.
Mr. JOHN HODGSON NICHOLSON, Cowpen Colliery Office, Blyth.
Mr. RICHARD LLEWELLYN WEEKS, Willington, S.O., County Durham.

TREASURER.

Mr. REGINALD GUTHRIE, Neville Hall, Newcastle-upon-Tyne.

HONORARY SECRETARY.

Mr. JOHN HERMAN MERIVALE, Neville Hall, Newcastle-upon-Tyne.

SECRETARY.

Mr. LAWRENCE AUSTIN, Neville Hall, Newcastle-upon-Tyne.

AUDITORS.

Messrs. JOHN G. BENSON and SONS, Newcastle-upon-Tyne.

BANKERS.

LLOYDS BANK LIMITED (LAMBTON'S BRANCH), Grey Street, Newcastle-upon-Tyne.

LIST OF MEMBERS,

AUGUST 1, 1908.

PATRONS.

His Grace the DUKE OF NORTHUMBERLAND.
The Most Honourable the MARQUESS OF LONDONDERRY.
The Right Honourable the EARL OF DURHAM.
The Right Honourable the EARL GREY.
The Right Honourable the EARL OF LONSDALE.
The Right Honourable the EARL OF WHARNCLIFFE.
The Right Reverend the LORD BISHOP OF DURHAM.
The Right Honourable LORD ALLENDALE
The Right Honourable LORD BARNARD.
The Right Honourable LORD RAVENSWORTH.
The Very Reverend the DEAN AND CHAPTER OF DURHAM.

HONORARY MEMBERS (Hon. M.I.M.E.).

* Honorary Members during term of office only.

	Date of Election.
1*JOHN BOLAND ATKINSON, H.M. Inspector of Mines, 2, Devonshire Terrace, Newcastle-upon-Tyne	Aug. 4, 1888
2*WILLIAM NICHOLAS ATKINSON, H.M. Inspector of Mines, Bridgend	Aug. 4, 1888
3*RICHARD DONALD BAIN, H.M. Inspector of Mines, Durham	Dec. 12, 1896
4*Prof. PETER PHILLIPS BEDSON, Armstrong College, Newcastle-upon-Tyne	Feb. 10, 1883
5 THOMAS BELL, 40, Esplanade Road, Scarborough	Dec. 12, 1896
6 JOSEPH DICKINSON, 3, South Bank, Sandy Lane, Pendleton, Manchester	Dec. 13, 1852
7 Prof. WILLIAM GARNETT, London County Council Education Office, Victoria Embankment, London, W.C.	Nov. 24, 1894
8*JOHN GERRARD, H.M. Inspector of Mines, Worsley, Manchester	June 11, 1892
9*FREDERICK AUGUSTUS GRAY, H.M. Inspector of Mines, 7, Victoria Square, Penarth	June 14, 1902
10*HENRY HALL, I.S.O., H.M. Inspector of Mines, Rainhill, S.O., Lancashire	March 4, 1876
11*HUGH JOHNSTONE, H.M. Inspector of Mines, Stafford ...	Oct. 13, 1906
12*Prof. GEORGE ALEXANDER LOUIS LEBOUR, Armstrong College, Newcastle-upon-Tyne. *Transactions* sent to Radcliffe House, Corbridge, S.O., Northumberland	Nov. 1, 1879
13*Prof. HENRY LOUIS, Armstrong College, Newcastle-upon-Tyne. *Transactions* sent to The Librarian, Armstrong College, Newcastle-upon-Tyne	Dec. 12, 1896
14*ROBERT McLAREN, H.M. Inspector of Mines, Craigmore, 77, Colinton Road, Edinburgh	Dec. 13, 1902
15*JOSEPH SAMUEL MARTIN, I.S.O., H.M. Inspector of Mines, The Vikings, 16, Durdham Park, Bristol	Aug. 4, 1888
16*JOHN MARTINE RONALDSON, H.M. Inspector of Mines, 44, Athole Gardens, Glasgow	Aug. 4, 1888
17*ARTHUR HENRY STOKES, H.M. Inspector of Mines, Greenhill, Derby	Aug. 4, 1888
18*Prof. HENRY STROUD, Armstrong College, Newcastle-upon-Tyne	Nov. 5, 1892

	Date of Election.
19*JETHRO JUSTIMAN HARRIS TEALL, Director of the Geological Survey of the United Kingdom, 28, Jermyn Street, London, S.W.	Aug. 3, 1901
20*WILLIAM WALKER, H.M. Inspector of Mines, Doncaster	Oct. 14, 1905
21*Prof. ROBERT LUNAN WEIGHTON, Armstrong College, Newcastle-upon-Tyne	April 2, 1898

MEMBERS (M.I.M.E.).

Marked * have paid life composition.

	Date of Election and of Transfer
1 Abbott, Henry Arnold, H.M. Inspector of Mines, 1, Highbury, West Jesmond, Newcastle-upon-Tyne	Feb. 13, 1904
2 Abel, Walter Robert, 8, Queens Gardens, Benton, Newcastle-upon-Tyne	Dec. 8, 1906
3 Acutt, Sidney, The Barrett Gold-mining Company, Limited, Kaapoche Hoop, Transvaal	Dec. 10, 1904
4 Adair, Hubert, Gillfoot, Egremont, S.O., Cumberland	April 8, 1905
5 Adams, George Francis, Inspector of Mines in India, Dhanbaid, E.I. Railway, Manbhum District, Bengal, India	Aug. 5, 1905
6 Adams, Henry Hopper, Takapuna, Auckland, New Zealand	April 10, 1897
7 Adams, Phillip Francis Burnet, Surveyor-General for the Orange River Colony, Government Office, Bloemfontein, Orange River Colony, South Africa	Oct. 12, 1901
8 Adamson, Thomas, Giridih, East Indian Railway, Bengal, India	Feb. 10, 1894
9 Ainsworth, Herbert, P.O. Box 1553, Johannesburg, Transvaal	Feb. 14, 1903
10 Ainsworth, John W., Bridgewater Offices, Walkden, Manchester	Dec. 14, 1895
11 Aldridge, Walter Hull, Trail, British Columbia	Feb. 8, 1908
12 Allan, John Frederick, c/o The Caucasus Copper Company, Limited, Bond Court House, Walbrook, London, E.C.	A.M. Feb. 10, 1883 M. June 8, 1889
13 Allan, Philip, Mina de San Domingos, Mertola, Portugal	June 10, 1905
14 Allison, J. J. C., Woodland Collieries, Butterknowle, S.O., County Durham	A.M. Feb 13, 1886 M. June 8, 1889
15 Andersen, Carl, Sandy, Lincoln County, Nevada, U.S.A.	Oct. 8, 1904
16 Anderson, Robert Hay, Apartado Postal 866, Mexico, D.F.	Aug. 4, 1894
17 Anderson, Robert Simpson, Benwell View, Bentinck Road, Newcastle-upon-Tyne (*Member of Council*)	S. June 9, 1883 A.M. Aug. 4, 1888 M. Aug. 3, 1889
18 Andrews, Arthur, 10, Ashwood Terrace, Sunderland	Aug. 2, 1902
19 Andrews, Edward William, 4, Ashwood Terrace, Sunderland	Aug. 4, 1906
20*Angwin, Benjamin, The Bungalow, Carbis Bay, S.O., Cornwall	Nov. 24, 1894
21 Appleby, Harry Walton, c/o Kluchi Gold-mines, Limited, Sobolinaya, Trans-Baikal, Siberia	Oct. 8, 1898
22 Appleby, William Remsen, Minnesota School of Mines, The University of Minnesota, Minneapolis, Minnesota, U.S.A.	April 14, 1894
23 Archer, Thomas, Mardale Parade, Gateshead-upon-Tyne	July 2, 1872
24 Archer, William, Victoria Garesfield, Lintz Green, County Durham	A. Aug. 6, 1892 M. Aug. 3, 1895
25 Armstrong, George Herbert Archibald, Castle View, Chester-le-Street	April 8, 1905
26 Armstrong, Henry, Collingwood Buildings, Collingwood Street, Newcastle-upon-Tyne	A.M. April 14, 1883 M. June 8, 1889
27 Armstrong, William, Wingate, S.O., County Durham (Past-President, *Member of Council*)	S. April 7, 1867 M. Aug. 6, 1870
28 Arnold, Thomas, Castle Buildings, Llanelly	April 13, 1907

		Date of Election and of Transfer.
29	ASHMORE, GEORGE PERCY, South West African Company, Grootfontein, Swakopmund, Damaraland, South West Africa	Feb. 13, 1897
30	ATHERTON, THOMAS WILLIAM TURNER, c/o Miss Atherton, 21, Handel Mansions, Handel Street, London, W.C. ...	A.M. June 11, 1898 M. Dec. 10, 1898
31	ATHRON, HAROLD VIVIAN, Laburnum Cottage, Hindley, Wigan	Feb. 13, 1904
32	ATKINSON, JOHN BOLAND, H.M. Inspector of Mines, 2, Devonshire Terrace, Newcastle-upon-Tyne (VICE-PRESIDENT, *Member of Council*)	Oct. 11, 1902
33	ATKINSON, R. HUGH M. BUDDLE	April 10, 1897
34	ATTWOOD, ALFRED LIONEL, Remolinos, por Pedrola, Provincia de Zaragoza, Spain	Aug. 5, 1905
35	AUBREY, RICHARD CHARLES, 144, New Walk, Victoria Road, Leicester	Feb. 5, 1870
36	AXTELL, THOMAS, 12, Riversdale Terrace, Sunderland ...	Oct. 8, 1904
37	BAARE, FRITZ, Bochum, Westphalia, Germany	Aug. 3, 1907
38	BAGNOLI, UGO, Orbetello, Italy	Feb. 8, 1908
39	BAILES, THOMAS, Jesmond Gardens, Newcastle-upon-Tyne	Oct. 7, 1858
40	BAILEY, ARCHIBALD DUNCAN, c/o S. G. Bailey and Company, Limited, Stafford Mills, Stroud, Gloucestershire ...	Oct. 8, 1898
41	BAILEY, EDWARD TRENHOLM, c/o Royal Colonial Institute, Northumberland Avenue, London, W.C.	A.M. June 13, 1896 M. June 12, 1897
42	BAIN, RICHARD DONALD, H.M. Inspector of Mines, Durham (VICE-PRESIDENT, *Member of Council*)	S. March 1, 1873 M. Aug. 5, 1876
43	BAINBRIDGE, EMERSON, 146, Lauderdale Mansions, Maida Vale, London, W.	S. Dec. 3, 1863 M. Aug. 1, 1868
44	BAINBRIDGE, EMERSON MUSCHAMP, Shipcote, Newbiggin-by-the-Sea, S.O., Northumberland	Feb. 8, 1902
45	BALDWIN, IVO WILLIAM, Oakleigh, Ruardean, Mitcheldean, S.O., Gloucestershire	Feb. 10, 1900
46	BARBER, GEORGE MARRIOTT, Chinapas, Chihuahua, Mexico	April 28, 1900
47	BARKER, M. W., The Penhalonga Proprietary Mines, Limited, Penhalonga, Rhodesia, South Africa	April 8, 1893
48	BARNARD, ROBERT, Kuardih, Kalipahari P.O., Asansol, Bengal, India	Dec. 11, 1897
49	BARRASS, MATTHEW, Wheatley Hill Colliery Office, Thornley, S.O., County Durham	S. Feb. 9, 1884 A. Aug. 1, 1891 M. Dec. 8, 1900
50	BARRETT, CHARLES ROLLO, Whitehill Hall, Pelton Fell, S.O., County Durham	S. Nov. 7, 1874 A.M. Aug. 7, 1880 M. Dec. 11, 1886
51	BARROW, WILLIAM, Seaton Burn Colliery, Dudley, S.O., Northumberland	Feb. 8, 1902
52*	BARTHOLOMEW, CHARLES WILLIAM, Blakesley Hall, near Towcester	Dec. 4, 1875
53	BARTON, HENRY, Central Bank Chambers, Leeds	Oct. 13, 1900
54	BATES, MATTHEW JOHN, Highbury, Stocksfield, S.O., Northumberland	Feb. 11, 1905
55	BATES, SIDNEY, The Grange, Prudhoe, Ovingham, S.O., Northumberland (*Member of Council*)	A. Feb. 8, 1890 M. June 8, 1895
56	BATES, THOMAS L., Station Street, Waratah, New South Wales, Australia	Feb. 12, 1898
57	BATESON, WALTER REMINGTON, c/o Penny and Duncan, Oruro, Bolivia, South America	Feb. 11, 1905
58	BATEY, JOHN, St. Edmunds, Coleford, Bath	Dec. 5, 1868
59	BATEY, JOHN WRIGHT, Elmfield, Wylam, S.O., Northumberland	Feb. 9, 1901
60	BAWDEN, WILLIAM, Tolcarne House, Greta Street, Keswick	Feb. 10, 1906
61	BAYLISS, ERNEST JOHN, Inglenook, Beedell Avenue, Westcliff-on-Sea, Southend-on-Sea	April 13, 1901
62	BEARD, JAMES THOM, 640, Clay Avenue, Scranton, Pennsylvania, U.S.A.	Feb. 14, 1903

Date of Election and of Transfer.

63 BEKENN, ALEXANDER RICHARD, Dundee Coal Company, Limited, Talana, Natal, South Africa ... ... Feb. 9, 1907

64 BELL, JOSEPH FENWICK, Orchard House, North Biddick, Washington, S.O., County Durham ... ... April 12, 1902

65 BELL, REGINALD, 59, Hopwood Street, Barnsley ... ... Dec. 13, 1902

66 BELL, WALTER, c/o Pyman, Bell and Company, Hull ... S. Oct. 8, 1889
M. Feb. 10, 1894

67 BELL, WILLIAM, Plashetts, S.O., Northumberland ... ... S. Feb. 13, 1897
A. Aug. 6, 1904
M. Oct. 12, 1907

68 BELL, WILLIAM RALPH, Wearmouth Colliery, Sunderland A. Oct. 13, 1894
M. Dec. 12, 1903

69 BEMENT, ALBURTO, 2114, Fisher Building, Chicago, Illinois, U.S.A. ... ... Aug. 3, 1907

70 BENNETT, ALFRED HENRY, Bedminster, Easton, Kingswood and Parkfield Collieries, Limited, Easton Colliery, A.M. April 10, 1886
Bristol ... ... M. June 8, 1889

71 BENNETT, HENRY, No. 5, Calle Sauz, La Minas de Rio Tinto, Provincia de Huelva, Spain ... ... Dec. 9, 1899

72 BENSON, THOMAS WALTER, Collingwood Buildings, Collingwood Street, Newcastle-upon-Tyne (PAST-PRESIDENT, *Member of Council*) ... ... Aug. 2, 1866

73 BERKLEY, CUTHBERT, Highfield House, Durham ... ... Aug. 21, 1852

74 BERKLEY, RICHARD WILLIAM, Marley Hill, Swalwell, S.O., County Durham (*Member of Council*) ... ... S. Feb. 14, 1874
A.M. Aug. 7, 1880
M. June 8, 1889

75 BIGG-WITHER, HARRIS, The Mount, Gathurst, Wigan ... Jan. 19, 1895

76 BIGGE, DENYS LEIGHTON SELBY, 27, Mosley Street, Newcastle-upon-Tyne ... ... June 10, 1903

77 BIGLAND, HUBERT HALLAM, The Stones, Whitley Bay, S.O., Northumberland ... ... Dec. 14, 1901

78 BIGLAND, JOHN, Henknowle, Bishop Auckland ... ... June 3, 1857

79 BIRD, EDWARD ERSKINE, c/o George Elliot and Company, Limited, 16, Great George Street, Westminster, London, A.M. Aug. 5, 1905
S.W. ... ... M. Dec. 14, 1907

80 BLACKETT, WILLIAM CUTHBERT, Acorn Close, Sacriston, Durham (VICE-PRESIDENT, *Member of Council*) ... ... S. Nov. 4, 1876
A.M. Aug. 1, 1885
M. June 8, 1889

81 BLAIKLOCK, THOMAS HENDERSON, Bebside Colliery, Bebside, S.O., Northumberland ... ... April 13, 1901

82 BONNIWELL, PERCIVAL ORMOND, Cardeeth, 32, Rylett Crescent, Ravenscourt Park, London, W. ... ... Dec. 12, 1903

83 BOOKLESS, JAMES, 14, Wilson Terrace, Broughton Moor, Maryport ... ... Dec. 14, 1907

84 BORLASE, WILLIAM HENRY, Greenside Lodge, Glenridding, Penrith ... ... Aug. 4, 1894

85 BOWMAN, FRANCIS, Ouston Colliery Office, Chester-le-Street ... ... A. June 8, 1895
M. Feb. 13, 1904

86*BRACKEN, THOMAS WILSON, 40, Grey Street, Newcastle-upon-Tyne ... ... Oct. 14, 1899

87 BRADFORD, GEORGE, Milbanke, Darlington ... ... Oct. 11, 1890

88 BRAIDFORD, WILLIAM, Jun., South Garesfield Colliery, Lintz Green, County Durham ... ... June 14, 1902

89 BRAMWELL, HUGH, Great Western Colliery, near Pontypridd S. Oct. 4, 1879
A.M. Aug. 6, 1887
M. Aug. 3, 1889

90 BREAKELL, JOHN EDWIN, 14A, Mentone Mansions, Fulham Road, London, S.W. ... ... April 25, 1896

91*BRINELL, JOHAN AUGUST, Jernkontoret, Stockholm, Sweden June 9, 1900

92 BROAD, WALLACE, British P.O. Box 225, Shanghai, China April 28, 1900

93 BRODIGAN, CHARLES BERNARD, P.O. Box 3, Brakpan, Transvaal ... ... Oct. 13, 1906

94 BROMLY, ALFRED HAMMOND, a/c Pacific Copper Company, Zihuatanejo, Guerrero, Mexico ... ... Nov. 24, 1894

		Date of Election and of Transfer.
95	BROOME, GEORGE HERBERT, Westport, New Zealand ...	Oct. 9, 1897
96*	BROUGH, BENNETT HOOPER, 28, Victoria Street, London, S.W.	A.M. Dec. 10, 1887 M. June 8, 1889
97	BROUGH, THOMAS, New Seaham Colliery, Sunderland ...	S. Feb. 1, 1873 A.M. Aug. 2, 1879 M. June 8, 1889
98	BROWN, DOUGLAS PHILIP, The Old House, Sowerby, Thirsk	June 11, 1898
99	BROWN, JOHN CONNELL, Westport Coal Company, Limited, Denniston, New Zealand	Feb. 8, 1908
100	BROWN, ROBERT OUGHTON, Elswick Collieries, Newcastle-upon-Tyne	S. Oct. 8, 1892 A. Aug. 3, 1895 M. Oct. 12, 1901
101	BROWN, RALPH RICHARDSON, Pekin Syndicate, Limited, Honan, North China	Aug. 3, 1907
102	BROWN, W. FORSTER, Cefn Coed, Malpas, Newport, Monmouthshire	S. Aug. 6, 1887 M. Aug. 5, 1893
103	BROWNE, ROBERT JOHN	Feb. 10, 1906
104	BROWNING, WALTER JAMES, c/o Rio Tinto Company, Limited, Provincia de Huelva, Spain	Oct. 12, 1907
105	BRUCE, JOHN, Port Mulgrave, Hinderwell, S.O., Yorkshire	S. Feb. 14, 1874 A.M. Aug. 7, 1880 M. June 8, 1889
106	BRYHAM, WILLIAM, Bank House, Wigan	Dec. 8, 1900
107	BUCKLE, CHRISTOPHER ERNEST, Elmwood, Denville, Havant	Feb. 10, 1900
108	BULL, HENRY MATTHEWS, Bengal Coal Company, Limited, Rayhara, E. I. Railway, Palaman District, India ...	April 9, 1904
109	BULMAN, EDWARD HEMSLEY, The North Randfontein Gold-mining Company, Randfontein, Transvaal	Feb. 13, 1892
110	BULMAN, HARRISON FRANCIS, Leazes Hall, Burnopfield, S.O., County Durham	S. May 2, 1874 A.M. Aug. 6, 1881 M. June 8, 1889
111	BUNNING, CHARLES ZIETHEN, c/o The British Consular Agent, Panderma, Constantinople, Turkey	S. Dec. 6, 1873 A.M. Aug. 5, 1882 M. Oct. 8, 1887
112*	BURLS, HERBERT THOMAS, 11, Foulis Terrace, Onslow Gardens, London, S.W.	Feb. 9, 1889
113*	BURN, FRANK HAWTHORN, 9, Sandhill, Newcastle-upon-Tyne. *Transactions* sent to Floove Grange, Weedon, S.O., Northamptonshire	S. Feb. 9, 1889 A. Aug. 4, 1894 M. Aug. 3, 1895
114	BURNE, CECIL ALFRED, Ranelagh Cottage, High Wycombe	S. Aug. 4, 1894 M. Aug. 3, 1901
115	BURNETT, CUTHBERT, Grange Iron Works, Durham ...	June 8, 1895
116*	BURNS, DAVID, Vallum View, Belle Vue, Carlisle	May 5, 1877
117	BURTON, GEORGE AUGUSTUS, Liverton Grange, Loftus, S.O., Yorkshire	Dec. 9, 1905
118	BURTON, JOSEPH JAMES, Rosecroft, Nunthorpe, S.O., Yorkshire	April 12, 1902
119	BUTT, THOMAS PHILIP EDWARD, Randfontein Estates, Randfontein, Transvaal	Dec. 11, 1897
120	BUTTERS, CHARLES, 220, Crocker Building, San Francisco, California, U.S.A.	Feb. 10, 1894
121	CAREY, GASPARD ROBERT DE MUSSENDEN	Oct. 12, 1901
122	CAREY, JOSEPH MACLEOD, H.M. Inspector of Mines, Durham	April 4, 1903
123	CARNEGIE, ALFRED QUINTIN, 31, Manor House Road, Newcastle-upon-Tyne	Oct. 11, 1902
124	CARNES, CHARLES SPEARMAN, Marsden Hall, South Shields	Aug. 1, 1891
125	CARROLL, JAMES, Brilliant and St. George Gold-mine, Charters Towers, Queensland, Australia	Dec. 10, 1898
126	CARROLL, MILES T., Tananarive, Madagascar	Feb. 10, 1906
127	CASEBOURNE, AMBROSE CUBITT, 3, St. Nicholas' Buildings, Newcastle-upon-Tyne	June 9, 1906
128	CASEBOURNE, SAMUEL WARD JACKSON, Cleveland Terrace, Darlington	Dec. 10, 1904

Date of Election and of Transfer.

129 CASSON, WILLIAM WALTER, St. Bees, S.O., Cumberland ... Aug. 5, 1905

130 CHAMBERS, ARTHUR LEO, c/o The Messina Transvaal Development Company, Grenfell Camp, Pietersburg, Transvaal ... Feb. 8, 1902

131 CHAMBERS, J. S., 5, Joukovskaja, St. Petersburg, Russia Oct. 10, 1896

132 CHAMBERS, R. E., The Nova Scotia Steel Company, Limited, Bell Island, Newfoundland ... June 9, 1900

133 CHANNING, J. PARKE, 11, Broadway, New York City, U.S.A. ... April 25, 1896

134*CHAPPEL, WALTER RICHARD HAIGHTON, Ipok, Perak, Malay Peninsula ... Feb. 14, 1903

135 CHARLETON, ARTHUR GEORGE, 5, Avonmore Road, Kensington, London, W. ... Aug. 6, 1892

136 CHARLTON, WILLIAM, Guisborough ... Feb. 12, 1898

137 CHARLTON, WILLIAM JOHN, Ashington Colliery, Morpeth April 25, 1896

138 CHEESMAN, EDWARD TAYLOR, Claravale Colliery, Ryton, S.O., County Durham ... A. Aug. 2, 1890; M. Aug. 6, 1892

139 CHEESMAN, HERBERT, Hartlepool ... Aug. 6, 1892

140 CHEESMAN, ISAAC TAYLOR, Throckley Colliery, Newburn, S.O., Northumberland ... Feb. 1, 1873

141 CHEESMAN, NICHOLAS, Blucher Pit, Newburn, S.O., Northumberland ... Dec. 8, 1900

142 CHICKEN, BOURN RUSSELL, 212, Osborne Road, Jesmond, Newcastle-upon-Tyne ... Dec. 12, 1903

143 CHILDE, HENRY SLADE, 59, Westgate, Wakefield ... A.M. Feb. 12, 1887; M. Aug. 3, 1889

144 CHURCH, ROBERT WILLIAM, Dragon Villa, Durham ... S. Dec. 9, 1905; A. Aug. 3, 1907; M. Oct. 12, 1907

145 CLAGHORN, CLARENCE R., Northwestern Improvement Company, Headquarters Building, Tacoma, Washington, U.S.A. ... Aug. 5, 1899

146 CLARK, HENRY, Inglenook, Norton, Stockton-upon-Tees ... April 8, 1899

147 CLARK, ROBERT, Rothalie, Fife Road, Darlington ... Feb. 15, 1896

148 CLARK, ROBERT BLENKINSOP, Springwell Colliery, Gateshead-upon-Tyne ... S. May 3, 1873; M. Aug. 4, 1877

149 CLARK, WILLIAM HENRY, 108, Cantonment, Kamptee, C.P., India ... April 28, 1900

150 CLAUDET, ARTHUR CROZIER, 6 and 7, Coleman Street, London, E.C. ... Aug. 3, 1895

151 CLIFFORD, WILLIAM, Jeannette, Pennsylvania, U.S.A. ... Feb. 9, 1895

152 CLOUGH, JAMES, Bomarsund House, Bomarsund, Bedlington, S.O., Northumberland ... S. April 5, 1873; A.M. Aug. 3, 1878; M. June 8, 1889

153 COCHRANE, BRODIE, Low Gosforth House, Newcastle-upon-Tyne ... Dec. 6, 1866

154 COCKBURN, EVAN, The New River Company, Parral, Fayette County, West Virginia, U.S.A. ... A. Aug. 5, 1893; M. Dec. 8, 1906

155 COLLEY, JOHN, Indwe Railway, Collieries and Land Company, Limited, P.O. Box 4, Indwe, Cape Colony, South Africa ... Feb. 9, 1901

156*COLLINS, HUGH BROWN, Auchinbothie Estate Office, Kilmacolm, S.O., Renfrewshire ... April 14, 1894

157 COLLINS, VICTOR BUYERS, Lewis Street, Islington, *via* Newcastle, New South Wales, Australia ... June 11, 1904

158 COLQUHOUN, THOMAS GRANT, The Durban Navigation Collieries, Limited, Dannhauser, Natal, South Africa ... Dec. 14, 1898

159 COMMANS, ROBERT EDDEN, 6, Queen Street Place, London, E.C. ... Nov. 24, 1894

160 COMSTOCK, CHARLES WORTHINGTON, Boston Building, Denver, Colorado, U.S.A. ... June 10, 1905

161 COOK, JOSEPH, Washington Iron Works, Washington, S.O., County Durham ... May 8, 1869

Date of Election and of Transfer.

162 Cook, Joseph, Jun., Washington Iron Works, Washington, S.O., County Durham ... ... Oct. 9, 1897

163 Cook, James Falshaw, Washington Iron Works, Washington, S.O., County Durham ... ... Feb. 12, 1898

164 Cook, John Watson, Binchester Hall, Bishop Auckland... Oct. 14, 1893

165 Cooke, Henry Moore Annesley, The Champion Reef Gold-mining Company of India, Limited, Champion Reefs P.O., Mysore State, South India ... ... Dec. 12, 1896

166 Cooper, Percy Sidney James, The North Eastern Steel Company, Limited, Middlesbrough ... ... Feb. 8, 1908

167*Coppée, Evence, 71, Boulevard d'Anderlecht, Brussels, Belgium ... ... Feb. 9, 1907

168 Corbett, Vincent, Blackett Colliery, Haltwhistle, S.O., Northumberland ... ... A. June 11, 1898 M. Feb. 13, 1904

169 Corbett, Vincent Charles Stuart Wortley, Chilton Moor, Fence Houses ... ... Sept 3, 1870

170 Corlett, George Stephen, Wigan ... ... Dec. 12, 1891

171 Corning, Christopher Robert, 36, Wall Street, New York City, U.S.A. ... ... June 14, 1902

172 Coste, Eugene, 210, Poplar Plains Road, Toronto, Ontario, Canada... ... ... June 9, 1900

173 Coulson, Frank, Shamrock House, Durham (Retiring Vice-President, *Member of Council*) ... ... S. Aug. 1, 1868 M. Aug. 2, 1873

174 Couves, Harry Augustus, 116, Shortridge Terrace, Jesmond, Newcastle-upon-Tyne ... ... Feb. 10, 1906

175 Cowell, Edward, Shotton Colliery Offices, Shotton Colliery, Castle Eden, S.O., County Durham ... ... A. Oct. 8, 1904 M. June 20, 1908

176 Cowper-Coles, Sherard Osborn, Grosvenor Mansions, Victoria Street, Westminster, London, S.W. ... ... Dec. 9, 1899

177 Cox, John H., 10, St. George's Square, Sunderland... ... Feb. 6, 1875

178 Craster, Walter Spencer, P.O. Box 216, Kopje, Salisbury, Rhodesia, South Africa ... ... Dec. 8, 1900

179 Craven, Robert Henry, The Libiola Copper-mining Company, Limited, Sestri Levante, Italy ... ... Feb. 11, 1905

180 Crawford, James Mill, Fairlawn, Leasingthorne, Bishop Auckland ... ... Feb. 14, 1903

181 Crofton, Charles Arthur, Wansbeck Colliery Company, Limited, Morpeth ... ... S. Dec. 10, 1898 A. Aug. 1, 1903 M. Dec. 14, 1907

182 Crookston, Andrew White, 188, St. Vincent Street, Glasgow ... ... Dec. 14, 1895

183 Crosby, Arthur, Douglas Colliery, Limited, Balmoral, Transvaal ... ... A.M. Aug. 7, 1897 M. April 12, 1902

184 Cross, William Haslam, 77, King Street, Manchester ... Feb. 8, 1902

185 Croudace, Francis Henry Lambton, The Lodge, Lambton, Newcastle, New South Wales, Australia ... ... June 8, 1907

186 Croudace, Sydney, New Lambton, Newcastle, New South Wales, Australia ... ... June 8, 1907

187 Cruz y Diaz, Emiliano de la, Calle de Balmes, 88, Barcelona, Spain. *Transactions* sent to Ingeniero Director de los Minas de Ribas, Provincia de Gerona, Spain .. June 14, 1902

188 Cummings, John, Hamsterley Colliery, Ebchester, S.O., County Durham ... ... A. Aug. 2, 1902 M. Dec. 14, 1907

189 Cunningham, John Allan, P.O. Box 59, Dundee, Natal, South Africa ... ... Dec. 8, 1906

190 Currie, Walter, P.O. Box 220, Bulawayo, Rhodesia, South Africa ... ... April 25, 1896

191 Curry, George Alexander, Thornley House, Thornley, S.O., County Durham ... ... Oct. 12, 1907

192 Curry, Michael, Cornsay Colliery, Durham ... ... Aug. 6, 1898

193 Cutten, William Henry, Billiter Square Buildings, London, E.C. ... ... Aug. 5, 1899

194 Daggar Henry James, Afton, Church Street, Marrickville, New South Wales, Australia ... ... Oct. 12, 1901

		Date of Election and of Transfer.
195	Daglish, William Charlton, Littleburn Colliery, near Durham	Dec. 12, 1896
196	Dakers, William Robson, Tudhoe Colliery, Spennymoor	A.M. Oct. 14, 1882 M. Aug. 3, 1889
197	Dan, Takuma, Mitsui Mining Company, 1, Suruga-cho, Nihonbàshi-ku, Tokyo, Japan	April 14, 1894
198	Daniel, Peter Francis, Greymouth, New Zealand	April 8, 1893
199	Darling, Fenwick, Eldon Colliery, Eldon, Bishop Auckland	Nov. 6, 1875
200	Darlington, James, Black Park Colliery, Ruabon	S. Nov. 7, 1874 M. Aug. 4, 1877
201	Davidson, Allan Arthur, Casilla 6, Valparaiso, Chile, South America	April 13, 1907
202	Davies, David, Cowell House, Llanelly	Dec. 9, 1899
203	Davies, William Stephen, Tredegar Iron and Coal Company, Park Hill, Tredegar	Feb. 14, 1903
204	Davis, Charles Henry, South Yarmouth, Massachusetts, U.S.A.	Oct. 13, 1900
205	Daw, Albert William, 11, Queen Victoria Street, London, E.C.	June 12, 1897
206	Daw, John W., Walreddon Manor, Tavistock	Dec. 14, 1895
207	Dean, Harry, Eastbourne Gardens, Whitley Bay, S.O., Northumberland	June 10, 1905
208	Dean, John, The Wigan Coal and Iron Company, Limited, Wigan	Feb. 13, 1904
209	Dean, Samuel, 15, Woodland Grove, Blackpool	Oct. 13, 1906
210	Dees, James Gibson, Floraville, Whitehaven	Oct. 13, 1883
211	Denny, George A., 564, Salisbury House, London, E.C.	Dec. 8, 1894
212	Dick, William, 5, Avonmore Gardens, West Kensington, London, W.	April 13, 1907
213	Dickinson, Arthur, 353, Mansion House Chambers, 11, Queen Victoria Street, London, E.C.	April 14, 1894
214	Dietzsch, Ferdinand, 652-655, Salisbury House, London Wall, London, E.C.	Aug. 5, 1899
215*	Dingwall, William Burliston-Abigail, Apartado 13, Matehuala, San Luis Potosi, Mexico	Aug. 4, 1900
216	Ditmas, Francis Ivan Leslie, Chindwara, Central Provinces, India	A. June 11, 1898 M. June 14, 1902
217	Dives, Robert, Durban, Natal, South Africa	Feb. 8, 1902
218	Dixon, Charles Willis, Westport Coal Company, Limited, Denniston, New Zealand	Feb. 8, 1908
219	Dixon, David Watson, Lumpsey Mines, Brotton, S.O., Yorkshire	Nov. 2, 1872
220	Dixon, George, c/o Bird and Company, 100-101, Clive Street, Calcutta, India	S. June 13, 1896 A. Aug. 6, 1904 M. Dec. 8, 1906
221	Dixon, Jonathan, Westport Coal Company, Limited, Denniston, New Zealand	Oct. 13, 1894
222	Dixon, Joseph Armstrong, Shilbottle Colliery, Lesbury, S.O., Northumberland	Dec. 14, 1901
223*	Dixon, James Stedman, Fairleigh, Bothwell, Glasgow	Aug. 3, 1878
224	Dixon, Robert, Sankey Wire Mills and Ropeworks, Warrington	June 5, 1875
225	Dixon, William, Cleator, S.O., Cumberland	April 10, 1897
226	Dobb, Thomas Gilbert, Brick House, Westleigh, Leigh	Dec. 8, 1894
227	Dobbs, Joseph, Jarrow Colliery, Castlecomer, S.O., County Kilkenny	April 14, 1894
228	Dodd, Benjamin, Bearpark Colliery, Durham (*Member of Council*)	S. May 3, 1866 M. Aug. 1, 1868
229	Dodd, Michael, Rand Club, Johannesburg, Transvaal	S. Dec. 4, 1875 A.M. Aug. 7, 1880 M. June 8, 1889
230	Doise, Sosthenes, 1 bis, rue du Souvenir, Courbevoie (Seine), France	June 14, 1902

		Date of Election and of Transfer.
231	Donald, William E., Rhodesia Broken Hill, North Rhodesia, South Africa	Oct. 14, 1905
232*	Donkin, William, Mines Department, Macequece, Portuguese East Africa	S. Sept. 2, 1876 A.M. Aug. 1, 1885 M. June 8, 1889
233	Dormand, Ralph Brown, Cambois House, Cambois, Blyth	A. Dec. 9, 1893 M. Aug. 3, 1901
234	Douglas, Arthur Stanley, Low Beechburn Colliery Office, Crook, S.O., County Durham	Feb. 13, 1904
235*	Douglas, Charles Prattman, Thornbeck Hill, Carmel Road, Darlington	March 6, 1869
236	Douglas, James, 99, John Street, New York City, U.S.A.	Oct. 14, 1899
237	Douglas, Matthew Heckels, Usworth Colliery, Washington, S.O., County Durham	A.M. Aug. 2, 1879 M. Aug. 3, 1889
238	Douglas, Thomas, The Garth, Darlington (Past-President, *Member of Council*)	Aug. 21, 1852
239	Draper, William, Silksworth Colliery, Sunderland ...	A. Dec. 14, 1889 M. Dec. 12, 1903
240	Duncan, William Shaw, 17, Fenchurch Street, London, E.C.	Oct. 14, 1905
241	Dunkerton, Ernest Charles, 97, Holly Avenue, Newcastle-upon-Tyne	Feb. 9, 1907
242	Eastlake, Arthur William, Grosmont, Palace Road, Streatham Hill, London, S.W.	June 11, 1892
243	Ede, Henry Edward, Caherdaniel, Waterville, S.O., County Kerry...	July 14, 1896
244	Eden, Charles Hamilton, Glyn-Dderwen, Blackpill, S.O., Glamorgan	June 14, 1890
245	Edwards, Edward, Maindy Pit, Ocean Collieries, Ton Pentre, Pentre, Pontypridd	Feb. 9, 1895
246	Edwards, Herbert Francis, 104, Stanwell Road, Penarth	Oct. 12, 1901
247	Edwards, Owain Tudor, Mohpani Mines, C.P., India ...	Aug. 4, 1906
248	Eliet, Francis Constant André Benoni Elié du, Compagnie Lyonnaise de Madagascar, à Ambositra, Madagascar	Aug. 3, 1901
249*	Elsdon, Robert William Barrow	April 13, 1901
250	Eltringham, George, Eltringham Colliery, Prudhoe, Ovingham, S.O., Northumberland	A. Dec. 8, 1894 M. Aug. 2, 1902
251	Elwen, Thomas Lee, Brandon Colliery, S.O., County Durham	Oct. 13, 1888
252	Embleton, Henry Cawood, Central Bank Chambers, Leeds	April 14, 1894
253	Englesqueville, René d', 7, rue Henri Martin, Paris, France	Feb. 8, 1908
254	English, John, Broomfield, Chopwell, Ebchester, S.O., County Durham	Dec. 9, 1899
255	English, William, North Walbottle Colliery, Newburn, S.O., Northumberland	Dec. 14, 1907
256	Epton, William Martin, Government Inspector of Machinery, Mines Department, Winchester House, Johannesburg, Transvaal	Oct. 12, 1895
257	Esmarch, Cecil August, 17, Collingwood Street, Newcastle-upon-Tyne	April 9, 1904
258	Etherington, John, 39a, King William Street, London Bridge, London, E.C.	Dec. 9, 1893
259	Evans, Lewis, The Robinson Central Deep, Limited, P.O. Box 1145, Johannesburg, Transvaal	Oct. 14, 1893
260	Everard, John Breedon, 6, Millstone Lane, Leicester	March 6, 1869
261	Fairley, James, Craghead and Holmside Collieries, Chester-le-Street	A.M. Aug. 7, 1880 M. Aug. 3, 1889
262	Fangen, Stener August, Aktieselskabet Norsk Malmexport, Kaljord pr. Kvitnes, Vesteraalen, Norway ...	April 9, 1904

		Date of Election and of Transfer.
263	FAWCETT, EDWARD STOKER, Battle Hill House, Walker, Newcastle-upon-Tyne	A. June 11, 1892 M. Aug. 6, 1904
264	FELTON, JOHN ROBINSON, H.M. Inspector of Mines, Kenilworth, Newport Road, Stafford	S. June 8, 1901 M. June 10, 1905
265*	FENWICK, BARNABAS, 66, Manor House Road, Newcastle-upon-Tyne	Aug. 2, 1866
266	FERGIE, CHARLES, P.O. Box 64, Sydney, Nova Scotia ...	Dec. 9, 1893
267	FERGUSON, DAVID, 140, Hyndland Drive, Kelvinside, Glasgow	A.M. Dec. 8, 1883 M. Aug. 3, 1889
268	FERGUSON, JAMES, P.O. Box 98, Johannesburg, Transvaal	Dec. 12, 1896
269	FÈVRE, LUCIEN FRANCIS, 1, place Possoz (XVI^{e}), Paris, France	Feb. 8, 1908
270	FIELD, EDWIN RICHARD, Daylesford, Victoria, Australia ...	April 28, 1900
271	FIEUZET, EUGÈNE, 4, rue Saint Blaise, Bagnères de Bigorre, Hautes Pyrénées, France	Dec. 14, 1901
272	FIGARI, ALBERTO, Apartado 516, Lima, Peru, South America	April 25, 1896
273	FISHBACK, MARTIN, Guaranty Trust Building, El Paso, Texas, U.S.A.	April 12, 1902
274	FISHER, EDWARD ROBERT, Wansbeck, Ammanford, S.O., Carmarthenshire	A.M. Aug. 2, 1884 M. Aug. 3, 1889
275	FISHER, HENRY HERBERT, Calle Zapiola, 2075, Belgrano, near Buenos Aires, Argentine Republic, South America	Oct. 8, 1904
276	FLEMING, HENRY STUART, 1, Broadway, New York City, U.S.A.	June 10, 1905
277	FLETCHER, JAMES, State Colliery, Seddonville, New Zealand	Oct. 14, 1905
278	FLETCHER, LANCELOT HOLSTOCK, Allerdale Coal Company, Limited, Colliery Office, Workington	A.M. April 14, 1888 M. June 8, 1889
279*	FLETCHER, WALTER, The Hollins, Bolton	Dec. 14, 1895
280	FLINT, JOHN, Radcliffe House, Acklington, S.O., Northumberland...	Jan. 19, 1895
281	FOGG, LEWIS WARNER, Uniontown, Fayette County, Pensylvania, U.S.A.	Feb. 8, 1908
282	FORD, MARK, Washington Colliery, Washington Station, S.O., County Durham	Aug. 3, 1895
283	FORD, STANLEY HORACE, 5, Osborne Terrace, Ashley Down Road, Bristol	June 10, 1893
284	FORSTER, ALFRED LLEWELLYN, Newcastle and Gateshead Water Company, Engineer's Office, Pilgrim Street, Newcastle-upon-Tyne	June 8, 1901
285	FORSTER, JOHN HENRY BACON, Whitworth House, Spennymoor (*Member of Council*)	S. Nov. 24, 1894 A. Aug. 7, 1897 M. Feb. 10, 1900
286	FORSTER, JOSEPH WILLIAM, P.O. Box 2, Benoni, Transvaal	Feb. 13, 1904
287	FORSTER, RICHARD PERCIVAL, Mount Pleasant, Spennymoor	Feb. 14, 1903
288	FORSTER, THOMAS EMERSON, 3, Eldon Square, Newcastle-upon-Tyne (PRESIDENT, RETIRING VICE-PRESIDENT, *Member of Council*)	S. Oct. 7, 1876 A.M. Aug. 1, 1885 M. June 8, 1889
289	FOULIS, JOHN THOMAS, Durban House, Ramsey, S.O., Isle of Man	Feb. 9, 1907
290	FOX, GEORGE CHARLES, P.O. Box 1961, Johannesburg, Transvaal	Feb. 14, 1903
291	FRECHEVILLE, WILLIAM, High Wykehurst, Ewhurst, Guildford	Feb. 15, 1896
292	FRYAR, JOHN WILLIAM, Eastwood Collieries, near Nottingham	A. June 14, 1890 M. June 12, 1897
293	FRYAR, MARK, Denby Colliery, Derby	S. Oct. 7, 1876 A.M. Aug. 4, 1883 M. June 8, 1889
294	FRYAR, THOMAS LEWIS, Toowoomba, Queensland, Australia	Dec. 9, 1905
295	FRYER, GEORGE KELLETT, Bleak House, Broughton Moor, Maryport	Dec. 14, 1901
296	FUTERS, THOMAS CAMPBELL, 17, Balmoral Gardens, Monkseaton, Whitley Bay, S.O., Northumberland	Aug. 6, 1904

Date of Election and of Transfer.

297 GALLOWAY, THOMAS LINDSAY, 175, West George Street, Glasgow ... ... Sept. 2, 1876
298 GALLOWAY, WILLIAM, Cardiff ... ... April 23, 1887
299 GASCON Y MIRAMON, ANTONIO, Carranza, 8, Madrid, Spain ... ... Aug. 2, 1902
300 GIBSON, JAMES, c/o W. E. Robarts, Acutts Arcade, Durban, Natal, South Africa ... ... A.M. Dec. 9, 1899 M. Feb. 13. 1904
301 GIFFORD, HENRY J., The Champion Reef Gold-mining Company, Champion Reef, Mysore State, India ... Oct 14, 1893
302 GILLMAN, GUSTAVE, Aguilas, Provincia de Murcia, Spain Aug. 2, 1902
303 GIPPS, F. G. DE VISME, Stannary Hills Mines and Tramway Company, North Queensland, Australia... ... ... April 25, 1896
304 GLASS, ROBERT WILLIAM, Axwell Park Colliery, Swalwell, S.O., County Durham ... ... S. June 10, 1899 A. Aug. 1, 1903 M. Oct. 12, 1907
305 GONINON, RICHARD, Menzies Consolidated Gold-mines, Limited, Menzies, Western Australia ... ... June 10, 1906
306 GOODWIN, ROBERT HARVEY, Karabournou Mercury-mine, c/o C. Whittall and Company, Smyrna, Turkey ... Oct. 13, 1900
307 GOODWIN, WILLIAM LAWTON, School of Mining, Kingston, Ontario, Canada ... ... Feb. 11, 1899
308 GORE, HENRY, Victorian Gold Estates, Limited, National Mutual Buildings, 395, Collins Street, Melbourne, Victoria, Australia ... ... April 28, 1900
309 GOUGH, GEORGE HENRY, Singareni Collieries, Yellandu (Deccan), India ... ... Aug. 4, 1900
310 GOULDIE, JOSEPH, Prospect House, Winder, Frizington, S.O., Cumberland .. .. Aug. 5, 1893
311 GOWLAND, JOSEPH EDWIN, Mina Caridad, Aznalcollar, Sevilla, Spain ... ... June 11, 1904
312 GRAHAM, EDWARD, Jun., Bedlington Colliery, Bedlington, S.O., Northumberland ... ... Aug. 1, 1896
313 GRAVE, PERCY, Guadalajara, Estado de Jalisco, Mexico ... Oct. 13, 1900
314 GREAVES, J. O., Westgate, Wakefield... ... ... Aug. 7, 1862
315 GREEN, EDWIN HENRY, P.O. Box 1978, Johannesburg, Transvaal ... ... Aug. 1, 1903
316 GREEN, JOSEPH, Crag House, Ferry Hill ... . Dec. 13, 1902
317 GREEN, JOHN DAMPIER, P.O. Box 340, Johannesburg, Transvaal ... ... A.M. Dec. 14, 1901 M. Aug. 2, 1902
318 GREENER, GEORGE ALFRED, 6, Tyvica Crescent, Pontypridd Feb. 10, 1900
319 GREENER, THOMAS YOUNG, West Lodge, Crook, S.O., County Durham (VICE-PRESIDENT, *Member of Council*) S. July 2, 1872 A.M. Aug. 2, 1879 M. June 8, 1889
320 GREENWELL, ALLAN, 30 and 31, Furnival Street, Holborn, London, E.C.... ... ... Aug. 4, 1900
321 GREENWELL, ALAN LEONARD STAPYLTON, Windlestone Colliery, Ferry Hill ... ... S. Oct. 8, 1898 A. Aug. 5, 1905 M. Dec. 14, 1907
322 GREENWELL, GEORGE CLEMENTSON, Poynton, Stockport ... S. March 6, 1869 M. Aug. 3, 1872
323 GRESLEY, WILLIAM STUKELEY, Avenue Road, Duffield, Derby ... ... A.M. Oct. 5, 1878 M. Aug. 3, 1889
324 GRIBBEN, EDWARD ... ... April 9, 1904
325 GRIFFITH, NATHANIEL MAURICE, The Sondage Syndicate, Limited, Tilmanstone Sinking, Eythorne, Dover ... S. Nov. 24, 1894 M. Feb. 11, 1899
326 GRIFFITH, THOMAS, Maes Gwyn, Cymmer, Porth, Pontypridd ... ... April 9, 1904
327 GRIFFITH, WILLIAM, Waterloo House, Aberystwyth ... Dec. 9, 1893
328*GRUNDY, JAMES, Walthew House Farm, (Crooke Delivery), Wigan ... ... June 13, 1896
329 GULLACHSEN, BERENT CONRAD, Hotel Norge, Bergen, Norway ... ... S. April 8, 1905 M. Aug. 3, 1907
330 GUMMERSON, JAMES M., 35, Birkbeck Road, Acton, London, W. ... ... A.M. June 10, 1899 M. Dec. 12, 1903

			Date of Election and of Transfer.
331	HADDOCK, WILLIAM THOMAS, The Sheba Gold-mining Company, Limited, Eureka, Transvaal	S.	Oct. 7, 1876
		A.M.	Aug. 1, 1885
		M.	June 8, 1889
332	HALBAUM, HENRY WALLACE GREGORY, Horden Colliery, Horden, Sunderland		April 8, 1899
333	HALL, FREDERICK, Fernleigh, Highfield, Workington ...		Oct. 14, 1893
334	HALL, JOHN CHARLES, Black Boy Colliery, Bishop Auckland	A.	Dec. 14, 1889
		M.	Aug. 3, 1895
335	HALL, JOSEPH JOHN, Ashington Colliery, Morpeth ...		Dec. 10, 1904
336	HALL, MATTHIAS STOKOE, Springwell Villa, Bishop Auckland		Feb. 14, 1874
337	HALL, ROBERT WILLIAM, Thrislington Colliery, West Cornforth, S.O., County Durham	A.	Dec. 13, 1902
		M.	June 8, 1907
338	HALL, TOM, Ryhope Colliery, Sunderland		June 8, 1889
339	HALLAS, GEORGE HENRY, Huyton, Liverpool...	S.	Oct. 7, 1876
		A.M.	Aug. 4, 1883
		M.	June 8, 1889
340	HALLIMOND, WILLIAM TASKER, Crown Deep, Limited, P.O. Box 102, Fordsburg, Transvaal		Dec. 14, 1889
341	HALSE, EDWARD, 15, Clarendon Road, Notting Hill, London, W. All communications sent to Boxgrove, St. Margaret's Road, East Twickenham, Middlesex ..	A.M.	June 13, 1885
		M.	Aug. 3, 1889
342	HAMILTON, EDWARD, Rig Wood, Saltburn-by-the-Sea ...	S.	Nov. 1, 1873
		A.M.	Aug. 2, 1879
		M.	June 8, 1889
343	HANCE, HENRY MALKIN, Nagpur, Central Provinces, India		Oct. 12, 1907
344*	HANCOCK, HENRY LIPSON, Wallaroo and Moonta Mining and Smelting Company, Limited, Wallaroo, South Australia		Dec. 14, 1895
345	HANCOCK, HENRY RICHARD, 130, First Avenue, Manor Park, Essex	A.M.	Aug. 4, 1894
		M.	Nov. 24, 1894
346	HANN, ROBERT, Jun., Denehurst, Ferry Hill		Oct. 14, 1895
347	HANNAH, DAVID, Brynderwen, Ferndale, Pontypridd ...		Feb. 9, 1895
348	HARE, GEORGE, Seghill Colliery, Seghill, Dudley, S.O., Northumberland	A.	Feb. 12, 1898
		M.	Dec. 14, 1907
349	HARE, SAMUEL, Howlish Hall, Bishop Auckland	S.	Aug. 2, 1879
		M.	Aug. 1, 1891
350	HARLE, PETER, Page Bank Colliery, County Durham ...		Oct. 8. 1892
351	HARLE, RICHARD, Browney Colliery, Durham ...		April 7, 1877
352	HARLE, ROBERT ALFRED, Alma Cottage, Campbells Hill, West Maitland, New South Wales, Australia	A.	April 14, 1894
		M.	Oct. 12, 1901
353	HARRIS, DAVID, Elands Laagte Collieries, Limited, Elands Laagte, Natal, South Africa	A.M.	June 12, 1897
		M.	April 13, 1901
354	HARRIS, HOWARD, P.O. Box 752, Durban, Natal, South Africa		Aug. 7, 1897
355	HARRIS, WILLIAM SCORER, Kibblesworth, Gateshead-upon-Tyne	S.	Feb. 14, 1874
		A.M.	Aug. 7, 1880
		M.	June 8, 1889
356	HARRISON, CHARLES AUGUSTUS, North Eastern Railway, Newcastle-upon-Tyne		June 21, 1894
357	HARRISON, GEORGE BRABBON, H.M. Inspector of Mines, Swinton, Manchester		Aug. 6, 1892
358	HARRISON, WILLIAM B., Brownhills Collieries, near Walsall		April 6, 1867
359	HASELDEN, ARTHUR, Linares, Provincia de Jaen, Spain ...	A.M.	Dec. 11, 1897
		M.	April 2, 1898
360*	HAWKER, EDWARD WILLIAM, Adelaide Club, Adelaide, South Australia		Oct. 12, 1895
361	HAWKINS, THOMAS SPEAR, Millpond House, Hayle, S.O., Cornwall		Aug. 6, 1904
362	HEADS, ROBERT WILLIAM, 85, Raffles Chambers, Singapore		June 14, 1902
363	HEDLEY, ARTHUR MORTON, Blaydon Burn, Blaydon-upon-Tyne, S.O., County Durham (*Member of Council*) ...	A.	Nov. 24, 1894
		M.	Dec. 12, 1903
364	HEDLEY, SEPTIMUS H., Langholme, Roker, Sunderland ...	S.	Feb. 15, 1879
		A.M.	Aug. 1, 1885
		M.	Aug. 3, 1889
365	HEDLEY, WILLIAM, Eighton Lodge, Low Fell, Gateshead-upon-Tyne		Feb. 13, 1897

		Date of Election and of Transfer.
366	Heinze, F. Augustus, Butte, Montana, U.S.A.	Dec. 11, 1897
367	Heise, Fritz, Hernerstrasse, 45, Bochum, Germany ...	Aug. 5, 1905
368	Henderson, Charles, Cowpen Colliery Office, Blyth ...	Dec. 9, 1899
369	Hendy, John Cary Baker, Etherley, *via* Darlington ..	Oct. 14, 1893
370	Henriksen, Gudbrand, Inspector of Mines, Fjosanger, near Bergen, Norway	Aug. 6, 1904
371	Herrmann, Henry J. A., Lokken Grube, Meldalen, Norway	Dec. 10, 1898
372	Heslop, Christopher, Woodside, Marske Mill Lane, Saltburn-by-the-Sea	S. Feb. 1, 1868 M. Aug. 2, 1873
373	Heslop, Grainger, North Moor House, Sunderland ...	Oct. 5, 1872
374	Heslop, Michael, Rough Lea Colliery, Willington, S.O., County Durham	A. Feb. 10, 1894 M. June 21, 1894
375	Heslop, Septimus, New Beerbhoom Coal Company, Limited, Asansol, Bengal, India	Oct. 12, 1895
376	Heslop, Thomas, Randolph Colliery, Evenwood, Bishop Auckland	S. Oct. 2, 1880 A.M. Aug. 4, 1888 M. Aug. 3, 1889
377	Heslop, William Taylor, St. George's Colliery, Hatting Spruit, Natal, South Africa	Aug. 3, 1895
378	Hewitson, Thomas, Associated Northern Company, Kalgoorlie, Western Australia	Dec. 9, 1899
379*	Hewitt, George Colthurst, Serridge House, Coalpit Heath, Bristol	June 3, 1871
380	Hewlett, Alfred, Haseley Manor, Warwick	March 7, 1861
381	Hewlett, Erne, Ammanford Colliery Company, Limited, Ammanford, S.O., Carmarthenshire	Oct. 10, 1896
382	Hewlett, Howe, Clock Face Colliery, Sutton Oak, St. Helens	Feb. 13, 1904
383	Higson, Jacob, Crown Buildings, 18, Booth Street, Manchester	Aug. 7, 1862
384	Hill, Albert James, New Westminster, British Columbia	A.M. Dec. 10, 1898 M. Dec. 8, 1900
385	Hill, William, Hill Crest, Dordon, Tamworth	A.M. June 9, 1883 M. Aug. 3, 1889
386	Hilton, Thomas Worthington, Wigan Coal and Iron Company, Limited, Wigan	Aug. 3, 1865
387	Hindson, Thomas, Framwellgate Colliery, near Durham	Dec. 9, 1905
388	Hodgkin, Jonathan Edward, Shelleys, Darlington ...	Dec. 13, 1902
389	Hodgson, Jacob, Cornsay Colliery, Durham	June 8, 1895
390	Hogg, Charles Edward, 34 and 36, Gresham Street, London, E.C.	Oct. 12, 1895
391	Hogg, John, Thornley Colliery Office, Thornley, S.O., County Durham	Dec. 12, 1903
392	Holberton, Walter Twining, Compañía Estanífera de Llallagua, Llallagua, Bolivia, South America, *via* Buenos Aires i Tupiza	June 9, 1900
393	Holliday, Martin Forster, Langley Grove, Durham ...	May 1, 1875
394	Holliday, Norman Stanley, Boyne Villa, Langley Moor, Durham	S. April 10, 1897 M. Feb. 13, 1904
395	Homersham, Edwin Collett, The Randfontein Estates Company, Limited, Randfontein, Transvaal ...	Feb. 9, 1901
396	Homersham, Thomas Henry Collett, Vulcan Iron Works, Thornton Road, Bradford	Aug. 6, 1898
397	Hood, George, 9, Agents Terrace, Boldon Colliery, S.O., County Durham	Dec. 14, 1907
398	Hood, William Walker, Glyncornel, Llwynypia, Pontypridd	April 9, 1904
399	Hooper, Edward, Salisbury House, London Wall, London, E.C.	A.M. June 4, 1881 M. April 14, 1894
400	Hooper, James, Derwent, St. Agnes, Scorrier, S.O., Cornwall	Feb. 13, 1904
401	Hope, Charles Edward, Vancouver, British Columbia ...	Aug. 1, 1903
402	Hope, Edmund Louis, Abbottabad, N.W. Frontier, India	Oct. 9, 1897

	Date of Election and of Transfer.
403 Hopkins, Edward	Oct. 8, 1889
404 Hopwood, Howell Arthur, Poste Restante, G.P.O., Singapore	Oct. 12, 1907
405 Hopwood, Isaac John, c/o Post Office, Dunolly, Victoria, Australia	Oct. 12, 1907
406 Hopwood, William, Vron Haul, Buckley, Chester ...	Aug. 3, 1901
407 Horswill, Frederick J., 1218, Chesnut Street, Oakland, California, U.S.A.	Oct. 14, 1899
408 Horwood-Barrett, Harold, Torbay House, Stow Park Avenue, Newport, Monmouthshire	June 8, 1907
409 Hosking, James, P.O. Box 1617, Johannesburg, Transvaal	June 21, 1894
410*Hoskold, Carlos A. Lynes	June 8, 1895
411 House, John, 46, Park Road, Wigan	June 13, 1896
412 Howells, David	Feb. 13, 1904
413 Howes, Frank T., Singareni Collieries, Deccan, India ...	A. Dec. 10, 1892 M. Oct. 14, 1893
414 Howson, Charles, Harraton Colliery, Chester-le-Street	S. Dec. 14, 1901 A. Aug. 4, 1906 M. June 8, 1907
415 Humble, Ernest, Lawson Street, Hamilton, Newcastle, New South Wales, Australia	S. Feb. 14, 1903 A. Aug. 3, 1907 M. April 11, 1908
416 Humble, John, West Pelton House, Beamish, S.O., County Durham	Feb. 8, 1902
417 Humble, William, Lawson Street, Hamilton, Newcastle, New South Wales, Australia	Oct. 14, 1893
418 Humphris, Henry, Blaenau Festiniog	Oct. 13, 1900
419 Hunter, Christopher, Cowpen Colliery Office, Blyth ...	A. Dec. 10, 1892 M. Dec. 12, 1903
420 Hunter, Robert, Gympie, Queensland, Australia	June 14, 1902
421 Hurst, George, 9, Framlington Place, Newcastle-upon-Tyne	S. April 14, 1883 M. Aug. 1, 1891
422 Hutchinson, John William, Llwyncelyn House, Porth, near Pontypridd	Oct. 14, 1899
423 Hutton, John George, Barfield, East Maitland, New South Wales, Australia	Dec. 10, 1904
424 Hylton, Frederick William, Ryhope Colliery, Sunderland	Aug. 3, 1907
425 Inskipp, Dudley James, c/o James Inskipp, 61, Rutland Gardens, Hove, Brighton	June 8, 1907
426 Jackson, Edmund, Tangier Buildings, Whitehaven ...	April 8, 1905
427 Jackson, Walter Geoffrey, Bramham Hall, Boston Spa, S.O., Yorkshire	June 7, 1873
428 Jacob, Frederick Ernest	Dec. 12, 1903
429 Jacobs, Lionel Asher, Giridih, E.I.R., Bengal, India ..	S. Aug. 4, 1900 A. Aug. 4, 1906 M. April 13, 1907
430 James, William Henry Trewartha, Finsbury House, Blomfield Street, London, E.C.	Dec. 12, 1896
431 Jamieson, John William, Medomsley, S.O., County Durham	Aug. 2, 1902
432 Janitzky, Edward, Pymble, near Sydney, New South Wales, Australia	Aug. 6, 1904
433 Jefferson, Frederick, Whitburn Colliery, South Shields	Dec. 11, 1897
434 Jeffreys, James Henry, The Lisboa Mining and Development Company, Limited, 32, Great St. Helens, London, E.C.	Oct. 8, 1904
435 Jenkins, Philip Thomas, Gwylfa, Llansamlet, S.O. Glamorgan	Dec. 10, 1904
436 Jenkins, William, Ocean Collieries, Treorchy, Pontypridd	Dec. 6, 1862
437 Jennings, Thomas Bryant, P.O. Box 1565, Johannesburg, Transvaal	Dec. 10, 1904

		Date of Election and of Transfer.
438	JEPSON, HENRY, 39, North Bailey, Durham	S. July 2, 1872
		A.M. Aug. 2, 1879
		M. June 8, 1889
439*	JOBLING, THOMAS EDGAR, Bebside, S.O., Northumberland (*Member of Council*)	S. Oct. 7, 1876
		A.M. Aug. 4, 1883
		M. June 8, 1889
440	JOHNS, BENNET, Station Road, Keswick	Dec. 9, 1905
441*	JOHNS, JOHN HARRY (HENRY), P.O. Box 231, Johannesburg, Transvaal	June 21, 1894
442	JOHNSON, EDWARD	Dec. 9, 1905
443	JOHNSON, HENRY HOWARD, The Village Deep, Limited, P.O. Box 1145, Johannesburg, Transvaal	Feb. 13, 1904
444	JOHNSON, JAMES, Boldon Lodge, East Boldon, S.O., County Durham	A. Aug. 6, 1898
		M. Dec. 12, 1903
445	JOHNSTON, J. HOWARD, c/o Backus and Johnston, Lima, Peru, South America	Feb. 10, 1894
446	JOICEY, WILLIAM JAMES, Sunningdale Park, Berkshire ...	March 6, 1869
447	JONES, CLEMENT, Neath Colliery, Cessnock, New South Wales, Australia	Dec. 8, 1906
448	JONES, EVAN, Plas Cwmorthin, Blaenau Festiniog	April 13, 1907
449	JONES, JACOB CARLOS, Wollongong, New South Wales, Australia	Aug. 6, 1892
450	JONES, PERCY HOWARD, Ty Ceirios, Pontnewynydd, Pontypool	Oct. 11, 1902
451	JONES, THOMAS, 1, Princes Street, Great George Street, Westminster, London, S.W.	June 12, 1897
452	JORDAN, CECIL WILLIAM, Marlborough House, Marlborough Road, Roath, Cardiff	Dec. 14, 1907
453	JOYNES, JOHN JAMES, Ferndale, Lydbrook, Gloucestershire	Aug. 6, 1904
454	JUDD, HENRY ALEXANDER, 9, St. Mildred's Court, Poultry, London, E.C.	Oct. 8, 1898
455	KAYLL, ALFRED CHARLES, Gosforth, Newcastle-upon-Tyne	S. Oct. 7, 1876
		M. Aug. 3, 1889
456	KAYSER, HENRICH WILHELM FERDINAND, Launceston, Tasmania	Nov. 24, 1894
457	KEARNEY, JOSEPH MUSGRAVE, Wankie (Rhodesia) Coal, Railway and Exploration Company, Limited, Wankie, Rhodesia, South Africa	Aug. 1, 1903
458	KEIGHLEY, FREDERICK CHARLES, Uniontown, Fayette County, Pennsylvania, U.S.A.	Aug. 4, 1900
459	KELLETT, MATTHEW HENRY, St. Helen's Colliery, Bishop Auckland	S. April 11, 1891
		M. Aug. 3, 1895
460	KERR, ANDREW, New Brancepeth Colliery, Durham ...	Dec. 14, 1907
461	KERR, DAVID GILLESPIE, Rowandell, Chryston, Glasgow ...	Aug. 4, 1900
462	KIDD, THOMAS, Jun., Linares, Provincia de Jaen, Spain ...	Aug. 3, 1895
463	KIRBY, MATTHEW ROBSON, c/o Addison Langhorne Steavenson, Holywell Hall, Durham	S. June 9, 1900
		A. Aug. 1, 1903
		M. Oct. 12, 1907
464	KIRKBY, WILLIAM, c/o Aire and Calder Navigation, Leeds	A.M. April 2, 1898
		M. Aug. 6, 1904
465	KIRKUP, AUSTIN, Manor House, Penshaw, Fence Houses (*Member of Council*)	S. April 9, 1892
		M. June 12, 1897
466	KIRKUP, FREDERIC OCTAVIUS, Garesfield Colliery, Rowlands Gill, Newcastle-upon-Tyne	S. April 9, 1892
		A.M. April 25, 1896
		M. Feb. 14, 1903
467	KIRKUP, JOHN PHILIP, Burnhope, Durham (*Member of Council*)	April 11, 1891
468	KIRKUP, PHILIP, Leafield House, Birtley, S.O., County Durham (*Member of Council*)	S. March 2, 1878
		A.M. Aug. 7, 1886
		M. Aug. 3, 1889
469	KIRSOPP, JOHN, Jun., Lamesley, Gateshead-upon-Tyne ...	June 9, 1900
470	KIRTON, HUGH, Kimblesworth Colliery, Chester-le-Street ...	S. April 7, 1877
		A.M. Aug. 1, 1885
		M. June 8, 1889

		Date of Election and of Transfer.
471	KITCHIN, JAMES BATEMAN, Woodend House, Bigrigg, S.O., Cumberland	Aug. 5, 1905
472	KLEPETKO, FRANK, 307, Battery Park Building, 21-24, State Street, New York City, U.S.A.	Oct. 13, 1900
473*	KNOWLES, ROBERT, Ednaston Lodge, near Derby	April 10, 1886
474	KNOX, WILLIAM, Horden Colliery, Castle Eden, S.O., County Durham	Oct. 13, 1906
475	KONDO, R., c/o Furukawa Mining Office, 1, Icchome Taesucho, Kojimachi, Tokyo, Japan	June 21, 1894
476*	KWANG, KWONG YUNG, Lincheng Mines, Lincheng, Lu-Han Railway, *via* Peking, North China	June 8, 1895
477	KYLE, GEORGE ROBERT, 6, Ravensworth Road, Dunston, Gateshead-upon-Tyne	Dec. 14, 1907
478	LAMB, ROBERT ORMSTON, Hayton, How Mill, Carlisle	Aug. 2, 1866
479	LANCASTER, JOHN, Overslade, near Rugby	March 2, 1865
480	LANCASTER, JOHN, Auchenheath, S.O., Lanarkshire	Sept. 7, 1878
481*	LANDERO, CARLOS F. DE, Apartado 3, Pachuca, Mexico	Feb. 15, 1896
482*	LAPORTE, HENRY, 35, rue de Turin, Brussels, Belgium	May 5, 1877
483	LATHBURY, GRAHAM CAMPBELL, East Indian Railway Collieries, Giridih, E.I.R., Bengal, India	Feb. 14, 1903
484	LATIMER, HUGH, South Durham Colliery, Eldon, Bishop Auckland	S. Feb. 15, 1896 A. Aug. 1, 1903 M. Feb. 11, 1905
485	LAVERICK, JOHN WALES, 54, Manor House Road, Jesmond, Newcastle-upon-Tyne	A.M. Dec. 9, 1882 M. Aug. 3, 1889
486	LAWN, JAMES GUNSON, King Edward Mine, Camborne	July 14, 1896
487	LAWRENCE, HENRY, 13, Devonshire Place, Newcastle-upon-Tyne (*Member of Council*)	Aug. 1, 1868
488	LEACH, CHARLES CATTERALL, Seghill Colliery, Seghill, Dudley, S.O., Northumberland (*Member of Council*)	S. March 7, 1874 A.M. Aug. 6, 1881 M. Aug. 4, 1883
489	LEBOUR, GEORGE ALEXANDER LOUIS, Armstrong College, Newcastle-upon-Tyne, *Transactions* sent to Radcliffe House, Corbridge, S.O., Northumberland	Feb. 1, 1873
490	LECK, WILLIAM, H.M. Inspector of Mines, Cleator Moor, S.O., Cumberland	Nov. 24, 1894
491	LEE, JOHN WILSON RICHMOND, 70, St. Helen's Gardens, North Kensington, London, W.	Aug. 5, 1893
492	LEE, PERCY EWBANK, Pontop Colliery, Annfield Plain, S.O., County Durham	Feb. 11, 1905
493	LEE, RICHARD HENRY LOVELOCK, Tai Yuan Fu, Shansi, North China	Aug. 5, 1905
494	LEECH, ARTHUR HENRY, 11, King Street, Wigan	Feb. 9, 1901
495	LEWIS, SIR WILLIAM THOMAS, Bart., Mardy, Aberdare	Sept. 3, 1864
496	LIDDELL, HUGH, 2, May Street, Durham	Feb. 11, 1905
497	LIDDELL, JOHN MATTHEWS, Togston Hall, Acklington, S.O., Northumberland	S. March 6, 1875 A.M. Aug. 6, 1881 M. June 8, 1889
498	LIDSTER, RALPH, Langley Park Colliery, Durham	April 4, 1903
499	LISBOA, MIGUEL ARROJADO RIBEIRO, Rua Costa Gama, Villa Japurá, Petropolis, Rio de Janeiro, Brazil, South America	Aug. 5, 1905
500	LISHMAN, ROBERT RICHARDSON, Bretby Colliery, Burton-upon-Trent	S. June 9, 1883 M. Aug. 1, 1891
501	LISHMAN, THOMAS, Hetton Colliery, Hetton-le-Hole, S.O., County Durham	S. Nov. 5, 1870 M. Aug. 3, 1872
502	LISHMAN, TOM ALFRED, Harton Colliery, Tyne Dock, South Shields	S. Nov. 24, 1894 A. Aug. 7, 1897 M. April 13, 1901
503	LISHMAN, WILLIAM ERNEST, 4, Field House Terrace, Durham	June 10, 1893
504	LISLE, JAMES, Kroonstad Coal Estate Company, Limited, P.O. Box 118, Klerksdorp, Transvaal	S. July 2, 1872 A.M. Aug. 3, 1878 M. June 8, 1889

		Date of Election and of Transfer.
505	Liveing, Edward H., Brookfield House, Long Stanton, Cambridge	S. Sept. 1, 1877 A.M. Aug. 2, 1884 M. Aug. 3, 1889
506	Llewellin, David Morgan, Glanwern Offices, Pontypool	May 14, 1881
507	Lockwood, Alfred Andrew, 46, Marmora Road, Honor Oak, London, S.E.	June 12, 1897
508	Long, Ernest, c/o Miss Long, 6, Granville Avenue, Whalley Range, Manchester	Aug. 4, 1906
509	Longbotham, George Augustus, Ings Foundry, Wakefield	Oct. 12, 1907
510	Lonsdale, Talbot Richard, Malton Colliery, near Durham	June 14, 1902
511*	Louis, David Alexander, Savage Club, 6 and 7, Adelphi Terrace, London, W.C.	April 8, 1893
512	Louis, Henry, 4, Osborne Terrace, Newcastle-upon-Tyne (*Member of Council*)	Feb. 15, 1896
513	Lowdon, Thomas, Hamsteels, near Durham	Dec. 14, 1889
514	Lupton, Arnold, 7, Victoria Street, Westminster, London, S.W.	Nov. 6, 1869
515	Lyall, Edward, 4, Vane Terrace, Darlington	Oct. 14, 1905
516	Macarthur, James Duncan, Bangkok, Siam	Oct. 13, 1906
517	MacArthur, John Stewart, 74, York Street, Glasgow ...	April 8, 1893
518	McCarthy, Edward Thomas, 125, Victoria Street, London, S.W.	A.M. Oct. 8, 1887 M. Aug. 3, 1889
519	McCreath, James, 208, St. Vincent Street, Glasgow ...	March 5, 1870
520	McDonald, John Alexander, c/o James E. McDonald, 4, Chapel Street, Cripplegate, London, E.C.	June 9, 1900
521	McDowell, Benjamin Francis, c/o Percy Tarbutt and Company, P.O. Box 669, Bulawayo; Rhodesia, South Africa	Dec. 12, 1903
522	Macfarlane, Rienzi Walton, c/o Parral Foreign Club, Parral, Estado Chihuahua, Mexico, *via* New York ...	April 9, 1904
523	McGeachie, Duncan, West Wallsend, New South Wales, Australia	Nov. 24, 1894
524	McInerny, Augustin Joseph, 16, rue d'Autriche, Tunis ...	Aug. 4, 1906
525	McIntosh, Robert, Assistant Inspector of Mines, Dunedin, New Zealand	April 9, 1904
526	Mackintosh, James, Burrea Coal Company, Salanpur Colliery, Sitarampur, E.I.R., Bengal, India	Oct. 12, 1895
527	McLellan, Neil, Idsley House, Spennymoor	Dec. 13, 1902
528	McMurtrie, George Edwin James, Radstock, Bath ...	S. Aug. 2, 1884 M. Dec. 12, 1891
529	McMurtrie, James, 5, Belvedere Road, Durdham Park, Bristol	Nov. 7, 1863
530	McNeill, Bedford, 25a, Old Broad Street, London, E.C.	Dec. 11, 1897
531	Maddison, W. H. F., The Lindens, Darlington	June 14, 1890
532	Mallmann, Paul J., 65 and 66, Wool Exchange, Coleman Street, London, E.C.	Oct. 8, 1904
533	Mammatt, John Ernest, 1, Albion Place, Leeds	Aug. 3, 1865
534	Manning, Arthur Hope, P.O. Box 88, Heidelberg, Transvaal	Dec. 11, 1897
535*	Markham, Gervase E., Gloucester Villa, Darlington ...	S. Dec. 4, 1875 A.M. Aug. 7, 1880 M. June 8, 1889
536	Marks, Herbert T., c/o Royal Colonial Institute, Northumberland Avenue, London, W.C.	Oct. 12, 1901
537	Marley, Frederic Thomas, Damodapore Colliery, Nandi P.O., Raniganj, E.I.R., Bengal, India	S. Oct. 8, 1898 A. Aug. 5, 1905 M. Dec. 14, 1907
538	Marr, James Heppell, Castlecomer, S.O., County Kilkenny	A. Feb. 13, 1897 M. Dec. 12, 1903
539*	Marriott, Hugh Frederick, c/o Wernher, Beit and Company, 1, London Wall Buildings, London, E.C. ...	Dec. 12, 1896
540	Martin, Henry Stuart, c/o H. Eckstein and Company, Johannesburg, Transvaal	April 13, 1907
541	Martin, Henry William, Sherwood, Newport Road, Cardiff	Oct. 9, 1897
542	Martin, Tom Pattinson, 22, Station Road, Workington ...	April 4, 1903

			Date of Election and of Transfer.
543	MATHIESON, ALEXANDER, Hetton Colliery, Carrington, near Newcastle, New South Wales, Australia...		Nov. 5, 1892
544	MATTHEWS, FREDERICK BERKLEY, Lartington Hall, Darlington...	A.M.	Dec. 9, 1882
		M.	June 8, 1889
545	MATTHEWS, JOHN, c/o R. and W. Hawthorn, Newcastle-upon-Tyne	A.M.	April 11, 1885
		M.	Aug. 3, 1889
546	MAURICE, WILLIAM, Hucknall Torkard, Nottingham ...		Dec. 14, 1907
547	MAWSON, ROBERT BRYHAM, Elm Bank, Wigan		June 11, 1892
548	MAY, GEORGE, Clervaux Castle, Croft, Darlington (PAST-PRESIDENT, *Member of Council*)		March 6, 1862
549	MEIN, HENRY JOHNSON, Carterthorne Colliery, Toft Hill, Bishop Auckland		Dec. 9, 1899
550	MELLON, HENRY, Brook Lea, Askam, S.O., Lancashire ...		April 25, 1896
551	MENZIES, JOSEPH FREDERICK, Roslyn, Washington, U.S.A.		June 10, 1905
552	MERIVALE, CHARLES HERMAN, Middleton Estate and Colliery Company, Middleton, Leeds	S.	June 9, 1900
		A.	Aug. 6, 1904
		M.	Dec. 14, 1907
553	MERIVALE, JOHN HERMAN, Togston Hall, Acklington, S.O., Northumberland (PAST-PRESIDENT, *Member of Council*)		May 5, 1877
554	MERZ, CHARLES HESTERMAN, Collingwood Buildings, Collingwood Street, Newcastle-upon-Tyne		June 10, 1903
555	METCALF, ALFRED T., United Reefs (Sheba), Limited, Eureka City, De Kaap, South Africa		June 21, 1894
556	MIDDLETON, ROBERT, Sheep Scar Foundry, Leeds		Aug. 1, 1891
557	MILLER, JAMES, c/o George Miller, 367, Byars Road, Hillhead, Glasgow		Aug. 4, 1894
558	MILLER, JOHN HENRY, South Hetton, S.O., County Durham	A.	Dec. 8, 1894
		M.	April 4, 1903
559	MILLER, J. P. K., H. C. Frick Coke Company, Scottdale, Pennsylvania, U.S.A.		Dec. 14, 1895
560	MITCHINSON, ROBERT, Catchgate House, Annfield Plain, S.O., County Durham		Feb. 4, 1865
561	MOLENGRAAFF, GUSTAAF ADOLF FREDERIK, 43, van Stolberglaan, The Hague		Oct. 14, 1899
562	MONTGOMERY, ALEXANDER, State Mining Engineer, Department of Mines, Perth, Western Australia		Dec. 9, 1899
563	MOORE, MARSHALL GREENE, 840, Napoleon Street, Johnstown, Pennsylvania, U.S.A.		Feb. 11, 1905
564	MOORE, ROBERT THOMAS, 142, St. Vincent Street, Glasgow...		Oct. 8, 1892
565	MOORE, RICHARD WALKER, Somerset House, Whitehaven	S.	Nov. 5, 1870
		M.	Aug. 4, 1877
566	MOORE, WILLIAM, Loftus Mines, Loftus, S.O., Yorkshire ...	A.M.	Nov. 19, 1881
		M.	Aug. 3, 1889
567	MOREING, CHARLES ALGERNON, 20, Copthall Avenue, London, E.C.		Nov. 7, 1874
568	MORGAN, JOHN, Stanley Villa, Crook, S.O., County Durham		Dec. 9, 1905
569	MORISON, JOHN, 14, Saville Row, Newcastle-upon-Tyne (*Member of Council*)	A.M.	Dec. 4, 1880
		M.	Aug. 3, 1889
570	MORLAND-JOHNSON, EDWARD THOMAS, c/o H. T. Johnson, Railway Road, Urmston, Manchester		April 10, 1897
571	MORRIS, JOHN, Lydbrook Colliery, Lydbrook, Gloucestershire	A.	April 4, 1903
		M.	Aug. 6, 1904
572	MORRIS, WILLIAM, Waldridge Colliery, Chester-le-Street ...		Oct. 8. 1892
573	MORSE, WILLARD S., Seaford, Delaware, U.S.A.		June 13, 1896
574*	MORT, ARTHUR, Khost, N. W. R., Baluchistan, India ...		Dec. 9, 1899
575	MORTON, REGINALD CHARLES, 31, Broomhall Place, Sheffield		Aug. 3, 1907
576	MOUNT-HAES, ANDREW, 3, Bellasis Avenue, Streatham Hill, London, S.W.		Dec. 10, 1904
577	MOUNTAIN, WILLIAM CHARLES, The Hermitage, Gateshead-upon-Tyne (*Member of Council*)		April 9, 1892
578	MUNDLE, ARTHUR, Murton Chambers, 8, Grainger Street, Newcastle-upon-Tyne	S.	June 5, 1875
		M.	Aug. 4, 1877
579	MUNDLE, HARRY ARTHUR, High Marley Hill, Swalwell, S.O., County Durham		June 14, 1902

		Date of Election and of Transfer.
580	MURRAY, WILLIAM CUTHBERT, Clifton House, Sherburn Colliery Station, near Durham	June 10, 1903
581	NESBIT, JOHN STRAKER, Marley Hill Colliery, Swalwell, S.O., County Durham	S. Oct. 9, 1897 A. Aug. 5, 1905 M. Oct. 12, 1907
582	NESS, WILLIAM WATERS VAN, 622-623, Salisbury House, London Wall, London, E.C.	A.M. Aug. 7, 1897 M. Dec. 11, 1897
583	NEVIN, JOHN, Littlemoor House, Mirfield, S.O., Yorkshire	S. May 2, 1868 M. Aug. 5, 1871
584	NEWBERY, FREDERICK, 230, Camden Road, London, N.W.	A.M. April 2, 1898 M. Feb. 13, 1904
585	NEWBIGIN, HENRY THORNTON, 3, St. Nicholas' Buildings, Newcastle-upon-Tyne	Oct. 13, 1894
586	NICHOLSON, ARTHUR DARLING, H.M. Inspector of Mines, 2, Graingerville, Newcastle-upon-Tyne (*Member of Council*)	S. June 13, 1885 A. Aug. 4, 1894 M. Feb. 12, 1898
587	NICHOLSON, JOHN HODGSON, Cowpen Colliery Office, Blyth (*Member of Council*)	S. Oct. 1, 1881 A. Aug. 3, 1889 M. April 8, 1893
588	NICHOLSON, MARSHALL, Middleton Colliery, Leeds	Nov. 7, 1863
589	NIERSES, J. W., Kendwadih Colliery, Kusunda P.O., District Manbhoom, Bengal, India	Dec. 10, 1904
590	NISBET, NORMAN, Houghton Colliery Office, Houghton-le-Spring, S.O., County Durham	S. Nov. 24, 1894 A. Aug. 3, 1901 M. Aug. 6, 1904
591	NOBLE, THOMAS GEORGE, Sacriston Colliery, Durham ...	A. Feb. 13, 1892 M. June 8, 1895
592	NOGARA, BERNARDINO, Galata, Constantinople, Turkey ...	Dec. 14, 1907
593	NÔMI, AITARÔ, Hójó Colliery, Province of Buzen, Japan	Aug. 5, 1899
594	NORTHEY, ARTHUR ERNEST, Frias, c/o Señor José M. Restrepo, Honda, Republic of Colombia, South America	June 10, 1903
595	OAKES, FRANCIS JAMES, Jun., 58, Pearl Street, Boston, Massachusetts, U.S.A.	Feb. 10, 1900
596	OATES, ROBERT JOSEPH WILLIAM, Rewah State Collieries, Umaria, C. India, Bengal Nagpur Railway	S. Feb. 10, 1883 A.M. Aug. 1, 1891 M. Dec. 12, 1891
597	O'DONAHUE, THOMAS ALOYSIUS, 72, Swinley Road, Wigan	A.M. Dec. 14, 1895 M. Oct. 9, 1897
598	OLDHAM, GEORGE, 25, Western Hill, Durham	Nov. 5, 1892
599	OLSEN, ARNOLD CARL LOUIS, P.O. Box 1056, Johannesburg, Transvaal	Dec. 9, 1905
600	ORNSBY, EDWARD THOMAS, Benwell Colliery, Newcastle-upon-Tyne	Dec. 8, 1900
601	ORNSBY, ROBERT EMBLETON, Seaton Delaval Colliery, Northumberland	June 11, 1898
602	OSBORNE, FRANCIS DOUGLAS, Gopeng, Perak, Federated Malay States	Feb. 14, 1903
603*	OSHIMA, ROKURO, No. 121, Yoyogi, Toyotama-gun, Tokyo, Japan	April 10, 1897
604	OUGHTON, WILLIAM, Milburn House, Newcastle-upon-Tyne	Feb. 8, 1908
605	OWENS, WILLIAM DAVID, Lehigh Valley Coal Company, 239, Philadelphia Avenue, Pittston, Pennsylvania, U.S.A.	Feb. 11, 1905
606	PAGE, ARTHUR HERBERT SHEEPSHANKS, Escomb, Bishop Auckland	Aug. 3, 1907
607	PAGE, DAVIDGE, 17, Surrey Street, Strand, London, W.C.	A.M. Oct. 10, 1903 M. Oct. 14, 1905
608	PALEY, GEORGE, Glebe House, Whitburn, Sunderland ...	Oct. 12, 1901
609	PALMER, CLAUDE BOWES, Wardley Hall, Pelaw, Newcastle-upon-Tyne	A.M. Nov. 5, 1892 M. June 8, 1895

		Date of Election and of Transfer.
610	PALMER, HENRY, Medomsley, S.O., County Durham (RETIRING VICE-PRESIDENT, *Member of Council*)	S. Nov. 2, 1878 A.M. Aug. 4, 1883 M. Aug. 3, 1889
611	PAMELY, CALEB, 64, Cromwell Road, Bristol	S. Sept. 5, 1868 M. Aug. 5, 1877
612	PAMPLIN, ELIAH GEORGE, Cherry Hinton, Cambridge ...	Aug. 1, 1903
613	PARISH, CHARLES EDWARD, 31, Hanger Lane, Ealing, London, W.	Feb. 10, 1900
614	PARRINGTON, MATTHEW WILLIAM, Wearmouth Colliery, Sunderland (VICE-PRESIDENT, *Member of Council*) ..	S. Dec. 1, 1864 M. Aug. 6, 1870
615	PARRINGTON, THOMAS ELLIOT, Carley Hill, Monkwearmouth, Sunderland	S. Aug. 3, 1895 A. Aug. 1, 1903 M. Oct. 12, 1907
616	PARSONS, HON. CHARLES ALGERNON, Heaton Works, Newcastle-upon-Tyne	A.M. June 12, 1886 M. Aug. 3, 1889
617	PASCOE, THOMAS, Mount Boppy Gold-mining Company, Limited, Boppy Mountain, New South Wales, Australia	A.M. April 10, 1897 M. June 12, 1897
618	PATERSON, ANDREW JAMES	June 11, 1898
619	PAYNE, FRANCIS WILLIAM, Government Insurance Building, Dunedin, New Zealand	Feb. 11, 1905
620	PEAKE, R. CECIL, Cumberland House, Redbourn, St. Albans	S. Feb. 7, 1880 A.M. Aug. 7, 1886 M. Aug. 3, 1889
621	PEARSE, JOHN WALTER, Grivynée-lez-Liége, Belgium ...	June 10, 1899
622	PEARSON, CLEMENT ALFRED RITSON, South End Avenue, Darlington	June 11, 1904
623	PEDELTY, SIMON, Broomhill Colliery, Acklington, S.O., Northumberland	A. Dec. 10, 1892 M. Dec. 14, 1907
624	PEEL, ROBERT, New Brancepeth Colliery, Durham	Aug. 6, 1892
625	PEILE, WILLIAM, Kilmorie, Crowborough, Sussex ...	S. Oct. 1, 1863 M. Aug. 6, 1870
626	PERCY, FRANK, Mining College, Wigan. *Transactions* sent to The Librarian, Wigan Free Library, Wigan... ...	Dec. 12, 1903
627	PERCY, ROBERT MCLEOD, Karagandy Colliery, Spassky Copper-mines, Limited, Spassky Zabod, Akmolinsk, Siberia	Dec. 14, 1907
628	PHILLIPS, PERCY CLEMENT CAMPBELL, Wallsend Colliery, near Newcastle-upon-Tyne	June 10, 1903
629	PIERCY, WILLIAM, 32, Grainger Street West, Newcastle-upon-Tyne	June 11, 1904
630	PINGSTONE, GEORGE ARTHUR, P.O. Box 445, Bulawayo, Rhodesia, South Africa	A.M. June 11, 1898 M. Dec. 10, 1898
631	PLUMMER, JOHN, Bishop Auckland	June 8, 1889
632	POLLITZER, SAMUEL JOSEPH, Terrys Chambers, 14, Castlereagh Street, Sydney, New South Wales, Australia ...	April 12, 1902
633*	POORE, GEORGE BENTLEY, 1730, Cupouse Avenue, Scranton, Pennsylvania, U.S.A.	A.M. Dec. 10, 1898 M. April 8, 1899
634	PORTER, JOHN BONSALL, McGill University, Montreal, Quebec, Canada	Dec. 8, 1900
635	POTTER, ERNEST HENRY, Tilmanstone Sinking, Eythorne, Dover	Feb. 8, 1908
636	POWELL, CHARLES HENRY, International Mines, Limited, Biggenden, *via* Maryborough, Queensland, Australia ...	June 14, 1902
637	PREST, JOHN JOSEPH, Hardwick Hall, Castle Eden, S.O., County Durham	Feb. 9, 1901
638	PRICE, FRANCIS HOLBORROW GLYNN, Longlands Place, Swansea	June 10, 1899
639	PRICE, S. R., Dilston House, Corbridge, S.O., Northumberland	S. Nov. 3, 1877 A.M. Aug. 1, 1885 M. Aug. 3, 1889
640	PRICE, SAMUEL WARREN, The Wern, Peterston-super-Ely, Cardiff...	Aug. 3, 1895
641	PRINGLE, JOHN ARCHIBALD, c/o J. C. Reddie, 4, Earl's Court Square, London, S.W.	Dec. 10, 1898

		Date of Election and of Transfer.
642	PRINGLE, ROBERT WILLIAM, Norfolk House, Laurence Pountney Hill, London, E.C.	Aug. 1, 1903
643*	PRIOR, HON. EDWARD GAWLER, Victoria, British Columbia. *Transactions* sent to Thomas R. Stockett, Western Fuel Company, Nanaimo, British Columbia	Feb. 7, 1880
644	PULLON, JOSEPH THOMAS, Rowangarth, North Park Road, Roundhay, Leeds	Feb. 11, 1905
645	RAE, JOHN LIVINGTON CAMPBELL, 40, Church Street, Newcastle, New South Wales, Australia	Oct. 14, 1899
646	RAINE, FREDERICK JAMES, Etherley Grange Colliery, Bishop Auckland	S. Feb. 15, 1896 A. Aug. 6, 1904 M. Feb. 9, 1907
647	RAMSAY, JOHN, Tursdale Colliery, Ferry Hill	A. April 27, 1895 M. Feb. 13, 1904
648	RAMSAY, WILLIAM HENRY, South Tanfield Colliery, Stanley, S.O., County Durham	June 8, 1907
649	RANDOLPH, BEVERLEY S., Barkeley Springs, West Virginia, U.S.A.	Aug. 4, 1894
650	RANKIN, THOMAS THOMSON, Mining and Technical College, Wigan	April 9, 1904
651	RATEAU, AUGUSTE, 7, rue Bayard, Paris, France ...	Aug. 2, 1902
652	RAVENSHAW, HENRY WILLOCK, Rutland House, Hanwell, London, W.	Feb. 15, 1896
653	RAY, CHARLES EDMUND, Whinfield, near Ulverston ...	Aug. 3, 1907
654	REDMAN, SYDNEY GEORGE, 15, Osborne Terrace, Gosforth, Newcastle-upon-Tyne	Feb. 10, 1906
655	REDWOOD, SIR BOVERTON, Wadham Lodge, Wadham Gardens, London, N.W.	June 21, 1894
656*	REES, ITHEL TREHARNE, Guildhall Chambers, Cardiff ...	April 4, 1903
657	REES, ROBERT THOMAS, Glandare, Aberdare	Aug. 7, 1897
658	REES, WILLIAM THOMAS, Maesyffynon, Aberdare ...	A.M. Oct. 9, 1897 M. Feb. 12, 1898
659	REID, ARTHUR H., P.O. Box 120, Cape Town, South Africa	June 21, 1894
660	REID, FRANCIS, Riverside, Blackboys, S.O., Sussex... ...	April 9, 1892
661	RENWICK, THOMAS CHARLTON, Lumley Thicks, Fence Houses	April 14, 1894
662	RHODES, CHARLES EDWARD, Lane End House, Rotherham	Aug. 4, 1883
663	RHODES, FRANCIS BELL FORSYTH, United States Zinc Company, Pueblo, Colorado, U.S.A.	Feb. 10, 1894
664	RICH, FRANCIS ARTHUR, Vincent Road, Remuera, Auckland, New Zealand	Aug. 5, 1899
665	RICH, WILLIAM, Trevu, Camborne	A.M. June 9, 1888 M. Aug. 3, 1889
666	RICHARDS, FRED, Blaenau, Compton Road, Canonbury, London, N.	Aug. 3, 1907
667	RICHARDS, THOMAS J., 53, Strand, Ferndale, Pontypridd	Oct. 10, 1896
668	RICHARDSON, HENRY, Eden Mount, Wetheral, Carlisle ...	March 2, 1865
669	RICHARDSON, NICHOLAS, c/o Mrs. James Richardson, South Ashfield, Newcastle-upon-Tyne	S. Dec. 12, 1896 A. Aug. 3, 1901 M. Dec. 14, 1901
670	RICHARDSON, ROBERT, Summerhill House, Blaydon-upon-Tyne, S.O., County Durham	A. Feb. 8, 1890 M. Aug. 3, 1895
671	RIDGE, HARRY MACKENZIE, Owton Manor, Seaton Carew, West Hartlepool	Dec. 14, 1907
672	RIDLEY, NORMAN BACKHOUSE, 2, Collingwood Street, Newcastle-upon-Tyne	June 8, 1895
673	RITSON, JOHN RIDLEY, Burnhope Colliery, Lanchester, Durham	S. April 11, 1891 A.M. Aug. 3, 1895 M. Feb. 14, 1903
674	RITSON, UTRICK ALEXANDER, Milburn House, Newcastle-upon-Tyne	Oct. 7, 1871
675	ROBBINS, PERCY ARTHUR, 60, Wall Street, New York City, U.S.A.	Oct. 12, 1901

Date of Election and of Transfer.

676 ROBERTS, JAMES, Jun., Perran House, Perranporth, S.O., Cornwall ... ... Dec. 14, 1895

677 ROBERTS, JOHN, Laxey, S.O., Isle of Man ... ... Dec. 9, 1905

678 ROBERTS, STEPHEN, Luipaards Vlei Estate and Gold-mining Company, P.O. Box 53, Krugersdorp, Transvaal ... April 28, 1900

679 ROBERTS, WILLIAM, Bella Vista, Perranporth, S.O., Cornwall ... ... Aug. 4, 1906

680 ROBERTSON, ANDREW, 49, Mining Exchange, Ballarat, Victoria, Australia ... ... Aug. 7, 1897

681 ROBERTSON, DANIEL ALEXANDER WILBERFORCE, Metropolitan Colliery, Helensburgh, near Sydney, New South Wales, Australia ... ... Aug. 6, 1892

682*ROBERTSON, JAMES ROBERT MILLAR, 40, Pitt Street, Sydney, New South Wales, Australia ... ... Aug. 2, 1890

683*ROBINS, SAMUEL MATTHEW, 28, Harefield Road, Brockley, London, S.E. *Transactions* sent to Thomas R. Stockett, Western Fuel Company, Nanaimo, British Columbia ... ... Oct. 12, 1895

684 ROBINSON, FRANCIS JAMES, Wycliffe, South Parade, Whitley Bay, S.O., Northumberland ... ... Oct. 13, 1906

685 ROBINSON, GEORGE, Boldon Colliery, S.O., County Durham June 10, 1899

686 ROBINSON, G. C., Brereton and Hayes Colliery, Rugeley ... Nov. 5, 1870

687 ROBINSON, GEORGE HENRY, Jun., Esplanade, Sunderland ... S. Dec. 9, 1899
M. April 8, 1905

688 ROBINSON, JOHN, High Hedgefield, Blaydon-upon-Tyne, S.O., County Durham ... ... Feb. 10, 1900

689 ROBINSON, J. B., Colliery Offices, Tow Law, S.O., County Durham ... ... Aug. 5, 1893

690 ROBINSON, JOHN THOMAS, South Medomsley Colliery, Dipton, S.O., County Durham ... ... Feb. 13, 1892

691 ROBINSON, ROBERT DOBSON, Tamworth Colliery Company, Tamworth ... ... Feb. 9, 1901

692 ROBINSON, TIMOTHY, Ryhope Colliery, Sunderland ... ... Feb. 8, 1902

693 ROBSON, J. S., Butterknowle Colliery, Butterknowle, S.O., County Durham ... ... May 15, 1862

694 RODEWALD, RUDOLF, Nenthead Mines, Nenthead, Alston, S.O., Cumberland ... ... April 7, 1906

695 ROELOFSEN, JEAN ADOLF, Post Office Buildings, Middlesbrough ... ... Aug. 3, 1907

696 RONALDSON, JAMES HENRY, P.O. Box 1763, Johannesburg, Transvaal ... ... Aug. 6, 1892

697 ROSS, HUGH, Dean and Chapter Colliery, Ferry Hill ... Aug. 6, 1892

698 ROSS, JOHN ALEXANDER GEORGE, 11, Kingsley Place, Heaton, Newcastle-upon-Tyne ... ... July 2, 1872

699 ROUTLEDGE, WILLIAM HENRY, Woodfield Park, Blackwood, Newport, Monmouthshire ... ... S. Oct. 7, 1876
A.M. Aug. 1, 1885
M. June 8, 1889

700 ROWE, JOSEPH SEYMOUR, Metropolitan Colliery, Helensburgh, New South Wales, Australia ... ... Aug. 3, 1907

701 ROWLEY, WALTER, 29, Park Row, Leeds ... ... Aug. 5, 1893

702 RUMBOLD, WILLIAM RICHARD, Oruro, Bolivia, South America, *via* Buenos Aires i Tupiza ... ... June 14, 1902

703 RUSSELL, ROBERT, Coltness Iron Works, Newmains, S.O., Lanarkshire ... ... Aug. 3, 1878

704 RUTHERFORD, ROBERT, Mainsforth, Ferry Hill ... ... Oct. 11, 1902

705 RUTHERFORD, WILLIAM, Lindum House, Gateshead-upon-Tyne ... ... Oct. 3, 1874

706 RUTHERFORD, WILLIAM, Jun., South Derwent Colliery, Annfield Plain, S.O., County Durham ... ... Feb. 9, 1901

707*SAISE, WALTER, Stapleton, Bristol ... ... A.M. Nov. 3, 1877
M. Aug. 3, 1889

708 SAM, THOMAS BIRCH FREEMAN, c o F. and A. Swanzy, Cape Coast Castle, West Africa ... ... Aug. 5, 1893

Date of Election and of Transfer.

709 SAMBORNE, JOHN STUKELY PALMER, Timsbury House, Bath ... . Aug. 1, 1891
710 SAMPLE, JAMES BERTRAM, Bunker Hill, Fence Houses ... S. Jan. 19, 1895
A. Aug. 4, 1900
M. Oct. 10, 1903

711*SAMWELL, NICHOLAS, c/o Alexander Forbes, 71, Phayre Street, Rangoon, Burma, India ... ... April 13, 1901
712 SANDOW, WILLIAM JOHN JOSIAH, 17, Fenchurch Street, London, E.C. ... ... Feb. 8, 1908
713 SAUNDERS, DAVID WILLIAM ALBAN, Worcester Chambers, Swansea ... ... A.M. Feb 12, 1898
M. June 11, 1898
714 SAUNDERS, WILLIAM THOMAS, Ivydene, West Cross, S.O., Glamorgan ... ... June 12, 1897
715*SAWYER, ARTHUR ROBERT, P.O. Box 2202, Johannesburg, Transvaal ... ... S. Dec. 6, 1873
A.M. Aug. 2, 1879
M. June 8, 1889

716 SCHNABEL, LEBERECHT FERDINAND RICHARD, Salisbury Buildings, 443, Bourke Street, Melbourne, Victoria, Australia ... ... April 13, 1907
717 SCHOLER, PETER, 117, Frances Street, Bellevue, Johannesburg, Transvaal ... ... A.M. Dec. 13, 1902
M. Feb. 10, 1906
718 SCHWARZ, PAUL, Otto House, Fleet Street, Bishop Auckland April 9, 1904
719 SCORER, JOHN, c/o J. Crawford and Sons, Limited, Bonnersfield Engine Works, Sunderland ... ... Dec. 12, 1903
720 SCOTT, ANTHONY, Netherton Colliery, Nedderton, Newcastle-upon-Tyne ... ... April 8, 1905
721 SCOTT, CHARLES F., Newbell, Consett, S.O., County Durham ... ... S. April 11, 1874
M. Aug. 4, 1877
722 SCOTT, ELGIN, Boryslaw, Galicia, Austria ... ... Aug. 4, 1894
723 SCOTT, ERNEST, Sun Buildings, Newcastle-upon-Tyne ... April 9, 1892
724 SCOTT, EDWARD CHARLTON, Woodside Cottage, Totley Rise, Sheffield ... ... A. Oct. 8, 1892
M. Feb. 11, 1899
725 SCOTT, FREDERICK BOWES, 28, Queen Street, London, E.C. Dec. 14, 1895
726 SCOTT, GEORGE HENRY HALL, c/o Thomas Emerson Forster, 3, Eldon Square, Newcastle-upon-Tyne ... ... S. April 12, 1902
M. Dec. 8, 1906
727 SCOTT, HERBERT KILBURN, 46, Queen Victoria Street, London, E.C. ... ... Oct. 11, 1902
728 SCOULAR, GEORGE, St. Bees, S.O., Cumberland ... ... July 2, 1872
729 SELBY, JOHN BASELEY, Leigh ... ... April 25, 1896
730 SENSTIUS, FRIEDRICH, Wester holter Weg, 43, Recklinghausen, Westphalia, Germany ... ... June 9, 1906
731 SEVERS, JOSEPH, North Walbottle, Newburn, S.O., Northumberland ... ... June 8, 1901
732 SEVERS, WILLIAM, Beamish, S.O., County Durham... ... A. Nov. 5, 1892
M. Dec. 8, 1900

733 SHANKS, JOHN, 10, Church Road, Harrington, S.O., Cumberland ... ... Aug. 5, 1905
734 SHARP, JACOB, Lambton House, Fence Houses ... ... Dec. 14, 1901
735*SHAW, JAMES, 41, Wicksteed Street, Wanganui, New Zealand ... ... Dec. 12, 1896
736 SHEAFER, ARTHUR WHITCOMB, Pottsville, Pennsylvania, U.S.A. ... ... Aug. 4, 1894
737 SHEWAN, THOMAS... ... ... Aug. 1, 1903
738 SHIEL, JOHN, 6, Windsor Terrace, Newcastle-upon-Tyne ... May 6, 1871
739 SIMON, FRANK, Rand Club, Johannesburg, Transvaal ... Dec. 14, 1895
740 SIMPSON, CHARLES LIDDELL, Engine Works, Grosvenor Road, Pimlico, London ... ... April 8, 1893
741 SIMPSON, FRANCIS L. G., Mohpani Coal-mines, Gadawarra, C.P., India ... ... A.M. Dec. 13, 1884
M. Aug. 3, 1889
742 SIMPSON, FRANK ROBERT, Hedgefield House, Blaydon-upon-Tyne, S.O., County Durham ... ... S. Aug. 4, 1883
M. Aug. 1, 1891
743 SIMPSON, JOHN, Heworth Colliery, Felling, S.O., County Durham (VICE-PRESIDENT, *Member of Council*) ... ... S. Dec. 6, 1866
M. Aug. 1, 1868
744 SIMPSON, JOHN BELL, Bradley Hall, Wylam, S.O., Northumberland (PAST-PRESIDENT, *Member of Council*) ... Oct. 4, 1860

		Date of Election and of Transfer.
745	SIMPSON, ROBERT ROWELL, Department of Mines, 6, Dacres Lane, Calcutta, India	S. Aug. 3, 1895 A. Aug. 2, 1902 M. Oct. 11, 1902
746	SIMPSON, THOMAS VENTRESS, Throckley Colliery, Newburn, S.O., Northumberland	S. Dec. 14, 1895 A. Aug. 2, 1902 M. Dec. 13, 1902
747	SKERTCHLEY, SYDNEY A. R., Tuxpam, Vera Cruz, Mexico	April 13, 1901
748	SLADDEN, HARRY, P.O. Box 2844, 6, Barnato Buildings, Johannesburg, Transvaal	Nov. 24, 1894
749	SLINN, THOMAS, 40, Park Avenue, Whitley Bay, S.O., Northumberland	July 2, 1872
750	SMALLWOOD, PERCY EDMUND, Garesfield Colliery, High Spen, Newcastle-upon-Tyne	A. Oct. 11, 1902 M. Oct. 12, 1907
751	SMART, ALEXANDER, c/o Frazer and Chalmers, Limited, Erith, S.O., Kent	Feb. 10, 1894
752*	SMITH, RICHARD CLIFFORD, Ashford Hall, Bakewell	Dec. 5, 1874
753	SMITH, ROBERT FLEMING, Hunters Villa, Parkside, Cleator Moor, S.O., Cumberland	Aug. 6, 1904
754	SMITH, WILLIAM, P.O. Box 653, Johannesburg, Transvaal	Oct. 11, 1902
755	SMITH, WILLIAM WOODEND, Crossgill House, Frizington, S.O., Cumberland	Aug. 6, 1904
756	SOPWITH, ARTHUR, Wavertree, Handsworth, Staffordshire	Aug. 6, 1863
757	SOUTHERN, EDMUND OCTAVIUS, North Seaton Hall, Morpeth	S. Dec. 5, 1874 A.M. Aug. 1, 1885 M. June 8, 1889
758	SOUTHERN, JOHN, Heworth Colliery, Felling, S.O., County Durham	A. Dec. 14, 1889 M. April 8, 1899
759	SOUTHERN, R. W. A., 33, The Parade, Cardiff	Aug. 3, 1865
760	SOUTHWOOD, REGINALD THOMAS ENFIELD, Nether House, Spencer Road, Putney, London, S.W.	Feb. 10, 1906
761	SPENCE, ROBERT FOSTER, Backworth, Newcastle-upon-Tyne	S. Nov. 2, 1878 A.M. Aug. 2, 1884 M. Aug. 4, 1889
762	SPENCER, FRANCIS H.	Dec. 13, 1890
763	SPENCER, JOHN WATSON, Newburn, S.O., Northumberland	May 4, 1878
764	STANLEY, GEORGE HARDY, Technical Institute, Johannesburg, Transvaal	April 12, 1902
765	STEAVENSON, ADDISON LANGHORNE, Durham (PAST-PRESIDENT, *Member of Council*)	Dec. 6, 1855
766	STEAVENSON, CHARLES HERBERT, Redheugh Colliery, Gateshead-upon-Tyne	S. April 14, 1883 A. Aug. 1, 1891 M. Aug. 3, 1895
767	STEEL, ROBERT, Woodhouse, Whitehaven	Aug. 5, 1905
768	STEPHENS, FRANCIS JOSEPH, Blackwell's Development Corporation, Limited, Knaben Grube, Fjotland, *via* Flekkefjord, Norway	Oct. 12, 1907
769	STEPHENSON, RALPH, West Stanley Colliery, Stanley, S.O., County Durham	Dec. 10, 1904
770	STEVENS, ARTHUR JAMES, Uskside Iron Works, Newport, Monmouthshire	April 8, 1893
771	STEVENS, JAMES, 9, Fenchurch Avenue, London, E.C.	Feb. 14, 1885
772	STEVINSON, PETER B., Dunholm, Lesbury Road, Heaton, Newcastle-upon-Tyne	April 9, 1904
773	STEWART, WILLIAM, Foxwood, Kent Road, Harrogate	S. Oct. 8, 1898 M. April 9, 1904
774	STEWART, WILLIAM, Tillery Collieries, Abertillery, S.O., Monmouthshire	June 8, 1895
775	STOBART, FRANK, Biddick Hall, Fence Houses	S. Aug. 2, 1873 A.M. Aug. 5, 1882 M. June 8, 1889
776	STOBART, HENRY TEMPLE, Wearmouth Colliery, Sunderland	S. Oct. 2, 1880 A.M. Aug. 4, 1888 M. Aug. 3, 1889
777	STOBART, WILLIAM RYDER, Etherley Collieries, County Durham	Oct. 11, 1890

		Date of Election and of Transfer.
778	STOKER, ARTHUR P., Ouston House, near Chester-le-Street	S. Oct. 6, 1877
		A.M. Aug. 1, 1885
		M. Aug. 3, 1889
779	STOKOE, JAMES, Herrington Lodge, West Herrington, *via* Sunderland	A. Nov. 24, 1894
		M. Dec. 10, 1904
780	STONE, ARTHUR, Heath Villas, Hindley, Wigan	June 13, 1896
781*	STONIER, GEORGE ALFRED, 726, Salisbury House, London, E.C.	June 11, 1904
782	STOREY, WILLIAM, Urpeth Villas, Beamish, S.O., County Durham	April 12, 1902
783	STRAKER, J. H., Howden Dene, Corbridge, S.O., Northumberland	Oct. 3, 1874
784	STREATFIELD, HUGH SIDNEY, Ryhope, Sunderland	A.M. June 8, 1889
		M. Aug. 3, 1889
785	STUART, DONALD MCDONALD DOUGLAS, Redland, Bristol	June 8, 1895
786	SULMAN, HENRY LIVINGSTONE, 44, London Wall, London, E.C.	Feb. 11, 1899
787	SUMMERBELL, RICHARD, Preston Colliery, North Shields	A. Dec. 9, 1905
		M. Dec. 14, 1907
788	SUTCLIFFE, RICHARD, Horbury, Wakefield	June 14, 1902
789	SUTHERLAND, EDGAR GREENHOW, West Rainton, Fence Houses	Dec. 10, 1904
790	SUTTON, WILLIAM, Grosmont, 46, Palace Road, Streatham Hill, London, S.W.	April 28, 1900
791	SWALLOW, JOHN, East Pontop Colliery, Annfield Plain, S.O., County Durham	May 2, 1874
792	SWALLOW, RALPH STOREY, Langley Park, Durham	A. Dec. 9, 1899
		M. Dec. 12, 1903
793	SWALLOW, WARDLE ASQUITH, Tanfield Lea, Tantobie, S.O., County Durham	S. Dec. 9, 1893
		A. Aug. 3, 1901
		M. Aug. 2, 1902
794	SWETE, OSWALD RICKETTS, Argosy Mine, Ngobevu, *via* Greytown, Natal, South Africa	June 9, 1906
795	SWINBURNE, UMFREVILLE PERCY, Inspector of Mines, Pretoria, Transvaal	A.M. Aug. 4, 1894
		M. June 14, 1902
796	SWINDLE, JACKSON, West House, Swalwell Road, Dunston, Gateshead-upon-Tyne	June 14, 1902
797	SWINNEY, ALFRED JOHN GEORGE, Lorne Villa, Elm Road, Sidcup, S.O., Kent	June 11, 1898
798	SYMONS, FRANCIS, Ulverston	Feb. 11, 1899
799	TALLIS, ALFRED SIMEON, The Rhyd, Tredegar	April 9, 1904
800	TALLIS, JOHN FOX, The Firs, Ebbw Vale, S.O., Monmouthshire	Dec. 12, 1903
801	TATE, SIMON, Trimdon Grange Colliery, County Durham	Sept. 11, 1875
802	TATE, WALKER OSWALD, Grange Hill, Bishop Auckland	S. Oct. 12, 1895
		A. Aug. 1, 1903
		M. Feb. 13, 1904
803	TAYLOR, ALFRED HENRY, Puponga Colliery, Collingwood, Nelson, New Zealand	Dec. 14, 1901
804	TAYLOR, NEIL, c/o The Falmouth Consolidated Mines, Limited, Wheal Jane Mine, Baldhu, near Truro	April 13, 1907
805	TAYLOR, THOMAS, Chipchase Castle, Wark, S.O., Northumberland	July 2, 1872
806	TEASDALE, THOMAS, Middridge, Heighington, S.O., County Durham	April 9, 1892
807	TELFORD, WILLIAM HAGGERSTONE, Hedley Hope Collieries, Tow Law, S.O., County Durham	S. Oct. 3, 1874
		A.M. Aug. 6, 1881
		M. June 8, 1889
808	TENNANT, JOHN THOMAS, James Street, Hamilton, Newcastle, New South Wales, Australia	Dec. 12, 1903
809	TERRY, ARTHUR MICHAEL, 23, Claremont Place, Gateshead-upon-Tyne	Aug. 6, 1904
810	TEUTENBERG, WILLIAM, Suedstrasse, 144K, Duisburg-Hochfeld, Westfalen, Germany	June 8, 1907

		Date of Election and of Transfer.
811	THOM, ARCHIBALD, Jun., Moresby Parks, near Whitehaven	Aug. 5, 1905
812	THOMAS, ARTHUR, Chilecito, Province Rioja, Argentine Republic, South America	Aug. 7, 1897
813	THOMAS, ERNEST HENRY, Oakhill, Gadlys, Aberdare ...	Feb. 10, 1900
814	THOMAS, ILTYD EDWARD, Glanymor, Swansea	Feb. 10, 1900
815	THOMAS, J. J., Hawthorn Villa, Kendal	June 21, 1894
816	THOMAS, RICHARD, Cambria Villa, Stockton, New South Wales, Australia	Feb. 11, 1899
817	THOMLINSON, WILLIAM, Seaton Carew, West Hartlepool ...	April 25, 1896
818	THOMPSON, ALFRED, Talbot House, Birtley, S.O., County Durham	Dec. 13, 1902
819	THOMPSON, CHARLES LACY, Farlam Hall, Brampton Junction, Carlisle	A.M. Feb. 10, 1883 M. Aug. 3, 1889
820	THOMPSON, ERRINGTON, Weardale House, St. John's Chapel, S.O., County Durham	June 8, 1907
821	THOMPSON, JOHN WILLIAM, East Holywell Colliery, Shiremoor, Newcastle-upon-Tyne	A. June 10, 1893 M. Feb. 10, 1900
822	THOMPSON, WILLIAM, 1 and 2, Great Winchester Street, London, E.C.	Aug. 4, 1888
823	THOMSON, JOHN, Eston Mines, by Middlesbrough	April 7, 1877
824	THOMSON, JOHN WHITFIELD	Oct. 11, 1902
825	THOMSON, THOMAS, Westport Coal Company, Limited, Denniston, New Zealand	Feb. 8, 1908
826	THORNTON, NORMAN MUSCHAMP, Seaton Burn and Dinnington Collieries, Seaton Burn, Dudley, S.O., Northumberland...	S. April 27, 1895 A. Aug. 2, 1902 M. June 10, 1903
827	TINSLEY, JAMES, Belgrave House, Brecon Road, Abergavenny	Dec. 12, 1903
828	TODD, JOHN THOMAS, Blackwell Collieries, Alfreton ...	S. Nov. 4, 1876 A.M. Aug. 1, 1885 M. June 8, 1889
829*	TOWNSEND, HARRY POYSER, c/o New Kleinfontein Company, Limited, P.O., Benoni, Transvaal...	April 12, 1902
830	TRELEASE, WILLIAM HENWOOD, Via dei Cattaneo, Novara, Italy ; and Ceppomorelli per Macugnaya, Vall' Anzasca, Prov. di Novara, Italy	April 8, 1893
831	TREVOR, EARLE WELLINGTON JENKS, c/o Nonex Safety Tank Company, 46, Dover Street, Piccadilly, London, W. ...	Aug. 2, 1902
832	TROTMAN, HENRY LEIGH, Moorland House, Aspull, Wigan	Feb. 13, 1904
833	TULIP, SAMUEL, Bunker Hill, Fence Houses	June 12, 1897
834	TURNBULL, JOHN JAMES, Jharia P.O., District Manbhoom, Bengal, India	Feb. 12, 1898
835	TURNBULL, ROBERT, Usworth Colliery, Washington, S.O., County Durham	Aug. 2, 1902
836	TURNER, CHARLES EDWARD, Mina Campanario, Valverde del Camuio, Provincia de Huelva, Spain	A.M. Aug. 6, 1898 M. June 20, 1908
837	TUXEN, PETER VILHELM, 60, Market Street, Melbourne, Victoria, Australia	April 7, 1906
838	TWEDDELL, GEORGE HERBERT, Edenholme, Beverley Gardens, Cullercoats, Whitley Bay, S.O., Northumberland	Feb. 13, 1904
839*	TYERS, JOHN EMANUEL, Rewah State Collieries, Umaria, Central India	A.M. Dec. 10, 1877 M. Aug. 3, 1889
840	TYRRELL, JOSEPH BURR, 87, Binscarth Road, Toronto, Canada	Feb. 10, 1900
841	TYZACK, DAVID, Bellingham, S.O., Northumberland ...	Feb. 14, 1874
842	UPTON, PRESCOTT, P.O. Box 1026, Johannesburg, Transvaal	June 12, 1897
843	VARTY, THOMAS, Skelton Park Mines, Skelton-in-Cleveland, S.O., Yorkshire	Feb. 12, 1887
844	VAUGHAN, CEDRIC, Hodbarrow Iron-ore Mines, Millom, S.O., Cumberland	Dec. 10, 1892
845	VEASEY, HARVEY C., Tetulmoorie, Sijua P.O., Manbhum District, Bengal, India	June 21, 1894

		Date of Election and of Transfer.
846	VERNY, GEORGE, Pont d'Aubenas, Ardéche, France ...	Oct. 8, 1898
847	VERSCHOYLE, WILLIAM DENHAM, Tanrago, Ballisodare, S.O., County Sligo	Dec. 11, 1897
848	WADHAM, WALTER FRANCIS AINSLIE, Millwood, Dalton-in-Furness, S.O., Lancashire	Dec. 10, 1898
849	WALES, HENRY THOMAS, Bank Chambers, Castle Square, Swansea	Feb. 11, 1893
850	WALKER, HENRY, H.M. Inspector of Mines, Durham ...	June 8, 1907
851	WALKER, JAMES HOWARD, Bank Chambers, Wigan ...	Dec. 9, 1899
852	WALKER, JOHN SCARISBRICK, Pagefield Iron Works, Wigan	Dec. 4, 1869
853	WALKER, SYDNEY FERRIS, Bloomfield Crescent, Bath ...	June 11, 1898
854	WALKER, THOMAS A., Pagefield Iron Works, Wigan ...	June 8, 1895
855	WALKER, WILLIAM EDWARD, Lowther Street, Whitehaven	Nov. 19, 1881
856	WALL, HENRY, Tower Buildings, Wallgate, Wigan ...	June 8, 1895
857	WALL, WILLIAM HENRY, Cumberland, British Columbia ...	June 14, 1902
858	WALSH, GEORGE PATON, 564, Heirengracht, Amsterdam, Holland	Nov. 24, 1894
859	WALTON, JONATHAN COULTHARD, Writhlington Colliery, Radstock, Bath	S. Nov. 7, 1874 A.M. Aug. 6, 1881 M. June 8, 1889
860	WALTON, WILLIAM HENRY, Bridgewater Offices, Walkden, Manchester	June 10, 1903
861	WARD, ALEXANDER HOUSTONNE, Raneegunge, Bengal, India	April 14, 1894
862*	WARD, THOMAS HENRY, Giridih, E.I.R., Bengal, East India	A.M. Aug. 5, 1882 M. Aug. 3, 1889
863	WATERS, STEPHEN, Apartado No. 96, Pachuca, Mexico ...	April 4, 1903
864	WATKYN-THOMAS, WILLIAM, Workington	A.M. Feb. 10, 1883 M. Aug. 3, 1889
865	WATSON, CLAUDE LESLIE, The Bengal Coal Company, Limited, Raneegunge, E.I.R., Bengal, India	Dec. 8, 1900
866	WATSON, EDWARD, c/o F. Harle, Solicitor, Chester-le-Street	S. Feb. 13, 1892 M. Aug. 4, 1894
867	WATSON, THOMAS, Trimdon Colliery, S.O., County Durham	Oct. 11, 1890
868	WATTS, FRANK REGINALD, Cleveland House, North Shields	Oct. 12, 1907
869	WATTS, J. WHIDBOURNE, P.O. Box 179, Barberton, Transvaal	Dec. 12, 1896
870	WEBSTER, ALFRED EDWARD, Manton, Worksop	June 12, 1897
871	WEDDERBURN, CHARLES MACLAGAN, 8, East Fettes Avenue, Edinburgh	Oct. 14, 1905
872	WEED, WALTER HARVEY, 42, Broadway, New York City, U.S.A.	June 14, 1902
873	WEEKS, JOHN GEORGE, Bedlington, S.O., Northumberland (PAST-PRESIDENT, *Member of Council*)	Feb. 4, 1865
874	WEEKS, RICHARD LLEWELLYN, Willington, S.O., County Durham (*Member of Council*)	A.M. June 10, 1882 M. Aug. 3, 1889
875*	WEINBERG, ERNEST ADOLPH, 39, Queen Street, Melbourne, Victoria, Australia	A.M. Feb. 12, 1898 M. Oct. 8, 1898
876	WELSH, THOMAS, Plas Darran, Abercynon, Pontypridd ...	Feb. 14, 1903
877	WELTON, WILLIAM PITT, Santa Ana, Departamento del Tolima, Republic of Colombia, South America	Dec. 9, 1905
878	WELTON, WILLIAM SHAKSPEARE, Elm Road, Wembley, S.O., Middlesex	Dec. 14, 1901
879	WESTERN, CHARLES ROBERT, Queen Anne's Mansions, Westminster, London, S.W.	June 10, 1893
880	WESTMACOTT, PERCY GRAHAM BUCHANAN, Rose Mount, Sunninghill, Ascot	June 2, 1866
881	WHITE, CHARLES EDWARD, Wellington Terrace, South Shields	S. Nov. 4, 1876 A.M. Aug. 1, 1885 M. Aug. 3, 1889
882	WHITE, FREDERICK NAPIER, H.M. Inspector of Mines, 12, St. James' Gardens, Swansea	June 11, 1898

Date of Election and of Transfer.

883 WHITE, HENRY, Walker Colliery, Newcastle-upon-Tyne ... S. March 2, 1867
M. Aug. 5, 1871

884 WHITEHEAD, JOHN JAMES, 20, Victoria Street, Westminster, London, S.W. ... ... Oct. 10, 1903

885 WIDDAS, C., North Bitchburn Colliery, Howden, Darlington ... ... Dec. 5, 1868

886 WIDDAS, HENRY, Whitehaven Castle Estate, Somerset House, Whitehaven ... ... April 7, 1906

887 WIDDAS, PERCY, Oakwood, Cockfield, S.O., County Durham Aug. 6, 1904

888 WIGHT, EDWARD SEPTIMUS, Taupiri Coal-mines, Limited, Mine-manager's Office, Huntly, near Auckland, New Zealand ... ... A.M. Dec. 12, 1885
M. Aug. 3, 1889

889 WIGHT, FREDERICK WILLIAM, 5, Bondicar Terrace, Blyth... Aug. 5, 1905

890 WIGHT, ROBERT TENNANT, Hallbankgate, Milton, Carlisle Oct. 13, 1900

891 WILBRAHAM, ARTHUR GEORGE BOOTLE, Mina de San Domingos, Mertola, Portugal ... ... S. Dec. 11, 1897
M. Feb. 8, 1902

892 WILD, MATTHEW BROWN, 37, Arthur Road, Erdington, Birmingham ... ... Oct. 12, 1907

893 WILKINS, WILLIAM GLYDE, Westinghouse Building, Pittsburg, Pennsylvania, U.S.A. ... ... Dec. 11, 1897

894 WILKINSON, JOHN THOMAS, Trimdon, Trimdon Grange, S.O., County Durham ... ... Dec. 8, 1900

895* WILKINSON, WILLIAM FISCHER, 43, Threadneedle Street, London, E.C. ... ... Oct. 10, 1896

896 WILLIAMS, FOSTER, Miniera di Libiola, Sestri Levante, Italy ... ... A. April 13, 1907
M. June 20, 1908

897 WILLIAMS, GARDNER FREDERICK, 2201, R Street, Washington, D.C., U.S.A. ... ... Oct. 12, 1895

898 WILLIAMS, GRIFFITH JOHN, H.M. Inspector of Mines, Bangor Aug. 2, 1902

899 WILLIAMS, HENRY J. CARNEGIE, Bruce Mines, Algoma, Ontario, Canada ... ... Oct. 12, 1895

900 WILLIAMS, ISAAC, Elterwater, Ambleside ... ... April 13, 1907

901 WILLIAMS, JAMES, c/o James Pollock, Sons and Company, Limited, 3, Lloyd's Avenue, London, E.C. ... ... April 11, 1908

902 WILLIAMS, JOHN, Dolavon, Llanrwst, S.O., Denbighshire Oct. 8, 1904

903 WILLIAMS, JOHN RICHARD, P.O. Box 149, Johannesburg, Transvaal ... ... June 11, 1904

904 WILLIAMS, JAMES WILSON, 15, Valley Drive, Harrogate ... April 4, 1903

905 WILLIAMS, LUKE, Claremont, Moonah, Tasmania ... ... April 10, 1897

906 WILLIAMS, ROBERT, 30, Clements Lane, Lombard Street, London, E.C. ... ... June 13, 1896

907 WILLIS, HENRY STEVENSON, Medomsley, S.O., County Durham ... ... S. Feb. 13, 1892
A. Aug. 4, 1900
M. June 8, 1907

908 WILSON, ANTHONY, Thornthwaite, Keswick ... ... A.M. Feb. 10, 1900
M. Dec. 13, 1902

909 WILSON, ARCHIBALD LAURENCE, The New Ravenswood, Limited, Ravenswood, Queensland, Australia ... ... A.M. June 12, 1897
M. April 2, 1898

910 WILSON, JAMES, Wellington House, Edmondsley, Durham April 13, 1901

911 WILSON, LLOYD, Flimby Colliery, Maryport ... ... Jan. 19, 1895

912 WILSON, NATHANIEL, 2, East India Avenue, Leadenhall Street, London, E.C. ... ... Dec. 9, 1899

913 WILSON, PEREGRINE OLIVER, c/o F. F. Wilson, 7, Devonshire Square, Bishopsgate Street, London, E.C. ... ... Dec. 9, 1893

914 WILSON, ROBERT GOTT, Battle Green, Pelton Fell, S.O., County Durham ... ... A. Aug. 6, 1892
M. Dec. 12, 1903

915 WILSON, WILLIAM, Chilton Colliery, *via* Ferry Hill ... June 8, 1907

916 WILSON, WILLIAM BRUMWELL, Horden Dene, Easington, Castle Eden, S.O., County Durham ... ... S. Feb. 6, 1869
M. Aug. 2, 1873

917* WILSON, WILLIAM BRUMWELL, Jun., Usworth Colliery, Washington, S.O., County Durham ... ... Feb. 9, 1901

918 WINCHELL, HORACE V., 505, Palace Building, Minneapolis, Minnesota, U.S.A. ... ... Nov. 24, 1894

919 WINSTANLEY, ROBERT, 42, Deansgate, Manchester ... ... Sept. 7, 1878

		Date of Election and of Transfer.
920	WITT, OTTO, Narvik, Norway	April 9, 1904
921	WOOD, ERNEST SEYMOUR, Cornwall House, Murton, S.O., County Durham	Oct. 10, 1891
922	WOOD, JOHN, Coxhoe Hall, Coxhoe, S.O., County Durham	S. June 8, 1889 A. Aug. 4, 1894 M. Aug. 3, 1895
923*	WOOD, SIR LINDSAY, Bart., The Hermitage, Chester-le-Street (PAST-PRESIDENT, *Member of Council*)	Oct. 1, 1857
924	WOOD, RICHARD, Barley Brook Foundry, Wigan	June 14, 1902
925	WOOD, ROBERT. 8, Olympia Gardens. Morpeth	April 13, 1907
926	WOOD, THOMAS, North Hetton Colliery Office, Moorsley, Hetton-le-Hole, S.O., County Durham	S. Sept. 3, 1870 M. Aug. 5, 1871
927	WOOD, THOMAS OUTTERSON, Cramlington House, Cramlington, S.O., Northumberland	Feb. 14, 1903
928	WOOD, WILLIAM HENRY, Coxhoe Hall, Coxhoe, S.O., County Durham	Aug. 6, 1857
929	WOOD, WILLIAM OUTTERSON, South Hetton, S.O., County Durham (PAST-PRESIDENT, *Member of Council*)	Nov. 7, 1863
930	WOODBURNE, THOMAS JACKSON, Bultfontein Mine, De Beers Consolidated Mines, Limited, Kimberley, South Africa	Feb. 10, 1894
931	WOODESON, WILLIAM ARMSTRONG, Clarke, Chapman and Company, Limited, Victoria Works, Gateshead-upon-Tyne	Dec. 10, 1904
932	WORMALD, CHARLES FREDERICK, Mayfield Villa, Saltwell, Gateshead-upon-Tyne	A.M. Dec. 8, 1883 M. Aug. 3, 1889
933	WRIGHT, ABRAHAM, East Indian Railway, Engineering Department, Giridih, Bengal, India	Feb. 11, 1905
934	WRIGHTSON, SIR THOMAS, Bart., Stockton-upon-Tees ...	Sept. 13, 1873
935	WRIGHTSON, WILFRID INGRAM, Neasham Hall, Darlington	A.M. Dec. 9, 1899 M. Feb. 8, 1908
936	YEOMAN, THOMAS PRESSICK, Ballarpur, Chanda District, Central Provinces, India	Aug. 1, 1903
937	YERBURY, FREDERICK AUGUSTUS, Hernosand, Esher Avenue, Walton-on-Thames	Oct. 13, 1906
938	YOULL, GIBSON, Bulli, New South Wales, Australia ...	Oct. 12, 1901
939	YOUNG, HARBEN ROBERT, Marshlands, Henley Street, Westport, New Zealand	Feb. 9, 1901
940	YOUNG, JAMES, 4, Granville Road, Jesmond, Newcastle-upon-Tyne	Oct. 9, 1897
941	YOUNG, JOHN ANDREW, 3, Fountain Avenue, Gateshead-upon-Tyne	A.M. Dec. 10, 1887 M. Aug. 3, 1889
942	YOUNG, JOHN HUNTLEY, Wearmouth Colliery, Sunderland	June 21, 1894

ASSOCIATE MEMBERS (Assoc. M.I.M.E.).

Marked * have paid life composition.

		Date of Election and of Transfer.
1	AINSWORTH, GEORGE, The Hall, Consett, S.O., County Durham	Dec. 9, 1905
2	ARMSTRONG, JOHN HOBART, St. Nicholas' Chambers, Newcastle-upon-Tyne	Aug. 1, 1885
3	ASPINALL, JOHN ECCLES, Post Office, Roodepoort, Transvaal	Feb. 13, 1904
4	ATKINSON, ALFRED, Clarke, Chapman and Company, Limited, Victoria Works, Gateshead-upon-Tyne	April 13, 1901
5	ATKINSON, GEORGE BLAXLAND, Prudential Assurance Buildings, Mosley Street, Newcastle-upon-Tyne ...	Nov. 5, 1892
6	BARRETT, WILLIAM SCOTT, Abbotsgate, Blundellsands, Liverpool	Oct. 14, 1899

		Date of Election and of Transfer.
7	Beauchamp, Frank B., Woodborough House, near Bath ...	Oct. 8, 1904
8*	Bell, Sir Hugh, Bart., Middlesbrough	Dec. 9, 1882
9	Bishop, Clarence Adrian, Engineering and Building Works, Mooi River, Natal, South Africa	Oct. 10, 1903
10	Borradaile, Noel Collingwood Dickson, Farm Sabonabon, near Motor Mine, Gatooma, Rhodesia, South Africa	Oct. 12, 1907
11*	Broadbent, Denis Ripley, Royal Societies Club, St. James' Street, London, S.W. *Transactions* sent to The Library, Royal Societies Club, St. James' Street, London, S.W.	Oct. 14, 1899
12	Brown, Edward Otto Forster, Springfort, Stoke Bishop, Bristol	S. Dec. 14, 1901 A. Aug. 3, 1907 A.M. Oct. 12, 1907
13	Brutton, P. M., 17, Sandhill, Newcastle-upon-Tyne ..	Oct. 13, 1900
14	Burdon, Augustus Edward, Hartford, Bedlington, S.O., Northumberland	Feb. 10, 1883
15	Burn, Charles William, 28, Fawcett Street, Sunderland	June 11, 1898
16	Cackett, James Thoburn, Pilgrim House, Newcastle-upon-Tyne	Oct. 10, 1903
17	Capell, Rev. George Marie, Passenham Rectory, Stony Stratford	Oct. 8, 1892
18*	Carr, William Cochran, Benwell Colliery, Newcastle-upon-Tyne	Oct. 11, 1890
19	Chambers, David Macdonald, 23, St. Mary's Mansions, Paddington, London, W.	Oct. 8, 1904
20*	Chewings, Charles, William Street, Hawthorn, South Australia	April 25, 1896
21	Cochrane, Ralph D., Hetton Colliery Offices, Fence Houses. *Transactions* sent to W. Cochrane, Willington Colliery Office, Willington, S.O., County Durham	June 1, 1878
22	Cooper, R. W., Newcastle-upon-Tyne	Sept. 4, 1880
23	Cope, William Henry, The University, Birmingham ...	Dec. 9, 1905
24	Cory, Sir Clifford John, Bart., c/o Cory Brothers and Company, Limited, Cardiff	Dec. 11, 1897
25	Cruttenden, William Courtenay Dawes, 31A, Colmore Row, Birmingham	June 11, 1904
26	Eastwood, William, 93, Scar Lane, Milnsbridge, Huddersfield	Dec. 8, 1906
27	Eccles, Edward, King Street, Newcastle-upon-Tyne ...	Oct. 13, 1894
28	Edwards, F. Henry, Bath Lane, Newcastle-upon-Tyne ...	June 11, 1887
29	Ellam, Albert Spencer, Camomile Street Chambers, Bishopsgate Street Within, London, E.C.	April 25, 1896
30	Ellis, Oswald William, 49, Beaumont Fee, Lincoln ...	Oct. 11, 1902
31	Fairless, Joseph, Mineral Traffic Manager, North Eastern Railway Company, Newcastle-upon-Tyne	June 10, 1899
32	Fenwick, Featherstone, County Chambers, Westgate Road, Newcastle-upon-Tyne	June 8, 1907
33	Ferguson, Colin Armstrong, P.O. Box 21, Randfontein, Transvaal	July 14, 1896
34	Foster, T. J., Coal Exchange, Scranton, Pennsylvania, U.S.A.	Dec. 12, 1891
35	George, Edward James, Beech Grove, Consett, S.O., County Durham	Dec. 9, 1905
36	Gibson, Thomas William, Bureau of Mines, Toronto, Ontario, Canada	June 8, 1901
37*	Graham, John, Findon Cottage, near Durham	Oct. 9, 1897
38	Graham, James Parmley, 26, Cloth Market, Newcastle-upon-Tyne	Dec. 8, 1906
39	Gunn, Scott, 18, John Street, Sunderland	Aug. 1, 1903
40	Guthrie, Reginald, Neville Hall, Newcastle-upon-Tyne (Treasurer, *Member of Council*)	Aug. 4, 1888

Date of Election and of Transfer.

41 Haanel, Eugene, Director of Mines, Department of Mines, Ottawa, Canada ... ... Aug. 1, 1903
42 Haggie, Arthur Jamieson, The Manor House, Long Benton, Newcastle-upon-Tyne ... ... Feb. 8, 1908
43 Hall, Charles, 196, Gresham House, London, E.C. ... Dec. 9, 1905
44 Harris-Edge, H. P., Coalport Works, Shifnal ... ... June 8, 1901
45 Haswell, William Spence, Beverley Gardens, Cullercoats, Whitley Bay, S.O., Northumberland ... ... April 13, 1901
46 Hedley, John Hunt, John Street, Sunderland ... ... June 13, 1891
47 Heeley, George, East Avenue, Benton, Newcastle-upon-Tyne ... ... Dec. 14, 1895
48 Henderson, Charles William Chipchase, c/o John George Weeks, Bedlington, S.O., Northumberland ... Dec. 9, 1882
49 Henzell, Robert, Northern Oil Works, Newcastle-upon-Tyne ... ... April 11, 1891
50 Hodgetts, Arthur, c/o G. W. Hodgetts, Vaal River Estate, Sydney, *via* Delpoort's Hope, District Kimberley, South Africa ... ... Oct. 9, 1897
51 Humphreys-Davies, George, 5, Laurence Pountney Lane, Cannon Street, London, E.C. ... ... Oct. 8, 1892

52 Innes, Thomas Snowball, Prudential Buildings, Mosley Street, Newcastle-upon-Tyne ... ... Dec. 10, 1898

53 James, Henry M., Colliery Office, Whitehaven ... ... June 10, 1893
54 Jeans, James Stephen, 165, Strand, London, W.C. ... April 2, 1898
55 Jeffrey, Joseph Andrew, c/o The Jeffrey Manufacturing Company, Columbus, Ohio, U.S.A. ... ... Dec. 11, 1897
56 Jeffries, Joshua, Hartley Street, Lambton, New South Wales, Australia ... ... Dec. 10, 1898
57*Joicey, James John, 62, Finchley Road, St. John's Wood, London, N.W. ... ... Oct. 10, 1891

58 Kidson, Arthur, c/o Glaholm and Robson, Limited, Rope Manufacturers, Sunderland ... ... April 8, 1899
59 Kirkley, James, Cleadon Park, Cleadon, Sunderland ... June 8, 1907
60 Krohn, Herman Alexander, 103, Cannon Street, London, E.C. ... ... Oct. 14, 1893

61 Lamb, Edmund George, Borden Wood, Liphook, S.O., Hants. ... ... Feb. 12, 1898
62 Lambert, Thomas, Town Hall Buildings, Gateshead-upon-Tyne ... ... Aug. 2, 1902
63 Langslow-Cock, Edward Arthur, H.M. Inspector of Mines, Mine Office, Seremban, Negri Sembilan, Federated Malay States ... ... Aug. 2, 1902
64 Latimer, William, 3, St. Nicholas' Buildings, Newcastle-upon-Tyne ... ... Oct. 14, 1905
65 Leake, Percy Collinson, c/o Deanbank Chemical Company, Ferry Hill ... ... Aug 3, 1907
66 Lishman, George Percy, Bunker Hill, Fence Houses ... Aug. 4, 1900
67 Loewenstein, Hans von Loewenstein zu, Friedrichstrasse, 2, Essen-Ruhr, Germany. *Transactions* sent to Bibliothek des Vereins für die bergbaulichen Interessen im Oberbergamtsbezirk Dortmund, Essen-Ruhr, Germany April 13, 1907

68 Marshall, Patrick, University School of Mines, Dunedin, New Zealand ... ... June 12, 1897
69 Morris, Percy Copeland, 79, Elm Park Gardens, London, S.W. ... ... Feb. 14, 1903

70 Ormrod, Wilson, Union Buildings, St. John Street, Newcastle-upon-Tyne ... ... Feb. 9, 1907

		Date of Election and of Transfer.
71	PALMER, ALFRED MOLYNEUX, John Bowes and Partners, Limited, Milburn House, Newcastle-upon-Tyne ...	Nov. 24, 1894
72	PICKERING, HENRY, 13, South Parade, Whitley Bay, S.O., Northumberland	Dec. 9, 1905
73*	PICKUP, P. W. D., Rishton Colliery, Rishton, Blackburn ...	Feb. 12, 1898
74	POSTLETHWAITE, JOHN, Chalcedony House, Eskin Place, Keswick	Feb. 11, 1905
75	PRIOR-WANDESFORDE, RICHARD HENRY, Castlecomer House, Castlecomer, S.O., County Kilkenny	Dec. 9, 1905
76*	PROCTOR, JOHN HENRY, 45, Percy Gardens, Tynemouth, North Shields	June 8, 1889
77	QUINCE, WILLIAM JOHN, P.O. Box 297, Pietermaritzburg, Natal, South Africa	April 8, 1905
78	REDMAYNE, ROBERT NORMAN, 14, Neville Street, Newcastle-upon-Tyne	Dec. 8, 1906
79	REID, SIDNEY, Printing Court Buildings, Newcastle-upon-Tyne	Dec. 13, 1902
80	RIDLEY, JAMES CARTMELL, 1, Bentinck Terrace, Newcastle-upon-Tyne	Feb. 11, 1893
81	ROGERSON, JOHN EDWIN, Oswald House, Durham	June 8, 1895
82	ROSEN, JOHN, P.O. Box 1647, Johannesburg, Transvaal ...	Dec. 10, 1898
83	RUSSELL, JAMES, Westgate Road, Newcastle-upon-Tyne ...	Feb. 13, 1904
84	SADLER, BASIL, Craigmore, Lanchester, Durham	Feb. 11, 1905
85	SAMUEL, DAVID, Ynyswen, New Road, Llanelly	Dec. 13, 1902
86	SANDBERG, CHRISTOPH GEORGE SIGISMUND, 8, Velperbinnensingel, Arnhem, Holland	Dec. 14, 1907
87	SANDERS, CHARLES WILLIAM HENRY, Sherburn House, near Durham	Dec. 14, 1901
88	SAUNDERS, GEORGE B., Saunders, Todd and Company, Maritime Buildings, King Street, Newcastle-upon-Tyne ...	Jan. 19, 1895
89	SCHUMACHER, RAYMOND WILLIAM, c/o H. Eckstein and Company, P.O. Box 149, Johannesburg, Transvaal ...	April 9, 1904
90	SCOTT, JOHN OLIVER, Milburn House, Newcastle-upon-Tyne	Dec. 11, 1897
91	SMITH, ARTHUR HERBERT, Broad Street House, London, E.C.	June 14, 1902
92	STEUART, DOUGLAS STUART-SPENS, Royal Societies Club, St. James' Street, London, S.W.	June 10, 1899
93	STRANGE, HAROLD FAIRBROTHER, P.O. Box 590, Johannesburg, Transvaal	Dec. 11, 1897
94	TODD, JAMES, Overdale, Jesmond, Newcastle-upon-Tyne ...	Aug. 6, 1892
95	VALENTINE, JAMES, 1, West View, Horwich, S.O., Lancashire	June 14, 1902
96	VOSKULE, GIDEON A., P.O. Box 1803, Johannesburg, Transvaal	Dec. 10, 1904
97	WALEY, FREDERICK GEORGE, The Bellambi Coal Company, Limited, 9, Bridge Street, Sydney, New South Wales, Australia	Feb. 9, 1907
98	WALKER, FREDERICK TILLOTSON, 70, Pilgrim Street, Newcastle-upon-Tyne	June 10, 1903
99	WALL, GEORGE YOUNG, Halmote Court Office, New Exchequer Building, Durham	Nov. 24, 1894
100	WALMESLEY, OSWALD, 2, Stone Buildings, Lincoln's Inn, London, W.C.	June 8, 1895
101	WELFORD, THOMAS, Wallarah Colliery, Catherine Hill Bay, New South Wales, Australia	June 10, 1903
102	WHITEHEAD, THOMAS, Brindle Lodge, Preston	June 12, 1897
103	WILLIAMS, HENRY, Llwyngwern, Pontardulais, S.O., Glamorgan	Dec. 9, 1905

Date of Election and of Transfer.

104*Wood, Arthur Nicholas Lindsay, The Hermitage, Chester-le-Street ... ... July 14, 1896

105 Young, Mrs. H. E., 617, Michigan Street, Victoria, British Columbia ... ... April 4, 1903

ASSOCIATES (Assoc. I.M.E.).

Marked * have paid life composition.

Date of Election and of Transfer.

1 Allan, Herbert Durham, Rewah State Collieries, Umaria, Central India, Bengal Nagpur Railway ... ... Feb. 10, 1906

2 Allport, Edward Aston ... ... S. April 14, 1894
A. Aug. 4, 1900

3 Annett, Hugh Clarkson, Widdrington, Acklington, S.O., Northumberland ... . S. Feb. 15, 1906
A. June 20, 1908

4 Archer, Matthew William, Grosvenor House, Manchester Road, Stocksbridge, Sheffield ... ... S. June 8, 1895
A. Aug. 4, 1900

5 Armstrong, Henry, South View House, Greenhill, Murton Colliery, *via* Sunderland ... ... Dec. 12, 1903

6 Armstrong, William, Jun., Chillaton Manganese-mines, Lewdown, S.O., Devon ... ... S. June 11, 1898
A. Aug. 6, 1904

7 Askew, Alfred Hill, 16, Telford Street, Gateshead-upon-Tyne ... . Feb. 9, 1907

8 Bamborough, Jacob, Preston Colliery, North Shields ... Oct. 8, 1904

9 Barrett, Rollo Samuel, Whitehill Hall, Pelton Fell, S.O., County Durham ... ... S. Dec. 9, 1905
A. Aug. 1, 1908

10 Bates, Johnson, 5, Grange Villa, S.O., County Durham ... Feb. 11, 1905

11 Bates, Thomas, West Wylam Terrace, Prudhoe, Ovingham, S.O., Northumberland .. .. April 13, 1907

12 Battey, Thomas, Station Road, Shiremoor, Newcastle-upon-Tyne ... ... Oct. 13, 1894

13 Bayldon, Harold Cresswell, Kotchkar, *via* Miass, Government of Orenburg, Russia ... ... S. April 2, 1898
A. Aug. 3, 1901

14 Bell, Harold Percy, Brookwell House, Gilcrux, Bullgill, S.O., Cumberland ... ... S. Aug. 2, 1902
A. Aug. 4, 1906

15 Benson, Herbert Sydney, Whitehill Farm, Chester-le-Street ... ... S. Feb. 11, 1905
A. Aug. 5, 1905

16 Bewick, George, Johnson Terrace, West Auckland, Bishop Auckland ... ... April 10, 1897

17 Bewley, Thomas, Stobswood Colliery, Acklington, S.O., Northumberland ... ... Aug. 5, 1905

18 Blair, Robert, 6, Hamilton Terrace, Whitehaven ... ... Aug. 2, 1902

19 Blandford, Thomas, Tresavean Mines, Limited, Lanner, Redruth ... ... S. Dec. 12, 1903
A. Aug. 3, 1907

20 Blunden, Philip Sidney, The Villas, Dean Bank, Ferry Hill Village, Ferry Hill ... ... June 8, 1907

21 Booth, Frederic Lancelot, Ashington Colliery, Morpeth S. Feb. 10, 1894
A. Aug. 4, 1900

22 Bowes, Thomas, Overdale, Catchgate, Annfield Plain, S.O., County Durham ... ... Feb. 13, 1892

23 Brandon, Geoffry, 9, Kensington Gardens, Monkseaton, Whitley Bay, S.O., Northumberland ... ... S. Dec. 8, 1900
A. Aug. 3, 1907

24 Burt, Thomas, Hill House, Washington, Washington Station, S.O., County Durham ... ... April 9, 1904

25 Carroll, John, Spring Bank House, Newfield, Willington, S.O., County Durham ... ... Feb. 12, 1898

26 Chapman, John, Tyzack Street, Edmondsley, Durham ... Dec. 14, 1907

27 Charlton, William John, Jun., 17, First Row, Ashington, Morpeth ... ... April 12, 1902

	Date of Election and of Transfer.
28 Cheesman, Matthew Forster, Throckley Colliery, Newburn, S.O., Northumberland	S. Dec 13, 1902
	A. Aug. 5, 1905
29 Clark, Nathaniel J., Belle Vue, Chester-le-Street	S. April 13, 1901
	A. Aug. 1, 1903
30 Clark, Thomas, Dipton Colliery, Lintz Green Station, County Durham	Oct. 11, 1890
31 Clifford, Edward Herbert, Rand Club, Johannesburg, Transvaal	S. Oct. 13, 1894
	A. Aug. 6, 1898
32 Clive, Robert, Bentley Colliery, near Doncaster	S. Feb. 10, 1900
	A. Aug. 1, 1903
33 Clough, Edward Stokoe, Bomarsund House, Bomarsund, Bedlington, S.O., Northumberland	Feb. 14, 1903
34 Clough, John, 1, Melton Terrace, Seaton Delaval, S.O., Northumberland	Feb. 13, 1897
35 Coade, Samuel, Steel Green, Millom, S.O., Cumberland	Dec. 10, 1904
36 Cockbain, Tom Stewartson, Usworth Colliery, Washington Station, S.O., County Durham	Dec. 8, 1906
37 Cockburn, John, Fatfield Road, Washington, S.O., County Durham	April 9, 1904
38 Cook, George, Binchester Hall, Bishop Auckland	S. Aug. 2, 1902
	A. Aug. 5, 1905
39 Cowx, H. F., Hilly View, Thornley, S.O., County Durham	April 14, 1894
40 Coxon, Samuel George, Hamsteels Colliery, Durham	Feb. 9, 1901
41 Coxon, William Bilton, South View, Crook, S.O., County Durham	S. Feb. 12, 1898
	A. Aug. 2, 1902
42 Crawford, Thomas, 9, Richmond Terrace, Felling, S.O., County Durham	Dec. 8, 1906
43 Crombie, Robert, Hollin Hurst House, Rowlands Gill, Newcastle-upon-Tyne	Dec. 9, 1905
44 Crowle, Percy, 51, Mainsgate Road, Millom, S.O., Cumberland	Feb. 11, 1905
45 Cummings, William, Beamish View, Stanley, S.O., County Durham	Dec. 14, 1907
46 Daglish, Frank, 1, Wilson Terrace, Broughton Moor, Maryport	Dec. 14, 1907
47 Danskin, Thomas, Springwell Colliery, Gateshead-upon-Tyne	Dec. 10, 1898
48 Davies, Daniel John, Corrimal, near Sydney, New South Wales, Australia	Oct. 12, 1907
49 Davis, James E., South Medomsley Colliery, Dipton, S.O., County Durham	Feb. 12, 1898
50 Davison, Francis, Ash Grove House, Hedley Hill Colliery, near Waterhouses, Durham	Feb. 12, 1898
51 Dick-Cleland, Archibald Felce, Ria Ora, Trelawny Road, Camborne	Dec. 8, 1906
52 Dixon, George, 14, Queens Square, Eastwood, Nottingham	S. Feb. 9, 1901
	A. Aug. 3, 1907
53 Dunnett, Samuel, West View House, Coomassie Road, Waterloo, Blyth	June 8, 1895
54 Eadie, John Allan, Jun., Eller Bank, Harrington, S.O., Cumberland	S. Oct. 10, 1903
	A. Aug. 5, 1905
55 Elliot, Arthur	S. Dec. 13, 1902
	A. Aug. 1, 1908
56 Elliott, George, Dinnington Colliery, Dudley, S.O., Northumberland	June 8, 1907
57 Elves, Edward, Parasea Collieries, Limited, Colliery Manager's Office, Chowkidanga P.O., Raneegunge, India	June 13, 1896
58 Emmerson, George, New Tetturya Coal Company, Limited, Manager's Office, Katrasgarh P.O., E.I.R., India	Oct. 8, 1898
59 Emmerson, Thomas, Warwick Terrace, New Silksworth, Sunderland	Oct. 12, 1907

	Date of Election and of Transfer.
60 ENGLISH, THOMAS WEDDLE, Halton Colliery, Whittington, Corbridge, S.O., Northumberland...	Feb. 11, 1905
61 ESKDALE, JOHN, Ashington Colliery, Morpeth	Oct. 11, 1902
62 FAIRBROTHER, CHARLES JAMES, Norman House, Broomhill, Acklington, S.O., Northumberland	Feb. 8, 1908
63 FALCON, MICHAEL, Llanarth Villas, Cross Keys, Newport, Monmouthshire	S. Oct. 13, 1894 A. Aug. 4, 1900
64 FIELD, BENJAMIN STARKS, Layabad Colliery, Kusunda P.O., District Manbhoom, Bengal, India	S. Aug. 2, 1902 A. Aug. 3, 1907
65 FOGGO, JOHN FREDERICK, Old Hall, Denby, Derby... .	S. June 14, 1902 A. Aug. 6, 1904
66 FORD, THOMAS, Blaydon Burn Colliery, Blaydon-upon-Tyne, S.O., County Durham	Aug. 2, 1902
67 FORSTER, EDWARD BATY, 15, Grange Road, Ryton, S.O., County Durham	April 7, 1906
68 FORSTER, FRANK, Black Hills Road, Horden Colliery, Castle Eden, S.O., County Durham	Feb. 8, 1902
69 FOWLER, ROBERT NORMAN, Staindrop House, Station Road, New Washington, Washington Station, S.O., County Durham	S. Aug. 2, 1902 A. Aug. 3, 1907
70 GALLAGHER, PATRICK, Clifton Row, Netherton Colliery, Nedderton, Newcastle-upon-Tyne...	Dec. 13, 1902
71 GALLOWAY, JOHN, St. Andrews House, Ayr	S. Dec. 13, 1902 A. Aug. 4, 1906
72 GILCHRIST, GEORGE ATKINSON, 17, Eldon Place, Newcastle-upon-Tyne	S. Dec. 14, 1901 A. Aug. 1, 1908
73 GORDON, GEORGE STOKER, 24, Louisa Terrace, Stanley, S.O., County Durham	Feb. 15, 1896
74 GORE-LANGTON, ROBERT LANCELOT, Hatch Park, Taunton	Feb. 10, 1906
75 GRAHAM, CECIL, Merton Villa, Vicarage Road, Chelstone, Torquay	S. April 4, 1903 A. Aug. 1, 1903
76 GRAHAM, ROBERT, 31, Railway Terrace, Willington, S.O., County Durham	Oct. 12, 1907
77 GREENWELL, GEORGE HAROLD, c/o Kilburn and Company, 4, Fairlie Place, Calcutta, India	S. Dec. 12, 1903 A. Aug. 4, 1906
78 GREY, JOHN NEIL, 20, St. Mary's Terrace, Ryton, S.O., County Durham	June 10, 1905
79 GUY, JOHN GEORGE, Manor House, Wardley Colliery, Newcastle-upon-Tyne	Dec. 8, 1906
80 HALL, JOSEPH PERCIVAL, West Stanley Colliery Offices, Stanley, S.O., County Durham	S. Oct. 9, 1897 A. Aug. 2, 1902
81 HAMPSON, ALEXANDER, St. Helen's Colliery, Bishop Auckland	Feb. 12, 1898
82 HANDYSIDE, WILLIAM, Jun., 4, Brandling Terrace, Felling, S.O., County Durham	June 12, 1897
83 HARPER, GEORGE OCTAVIOUS, Greenhead, Chopwell Colliery, Lintz Green, County Durham	S. Feb. 8, 1902 A. Aug. 3, 1907
84 HAWES, GEORGE ARTHUR, 141, Gurney Valley, Coundon Grange, Bishop Auckland	Dec. 12, 1903
85 HEAPS, CHRISTOPHER, 12, Richmond Terrace, Gateshead-upon-Tyne	S. Feb. 10, 1900 A. Aug. 4, 1906
86 HEDLEY, GEORGE WILLIAM, Alexander Terrace, Coach Lane Houses, Dinnington Colliery, Dudley, S.O., Northumberland	Dec. 13, 1902
87 HENDERSON, WILLIAM, 4, Beatrice Terrace, New Herrington, Philadelphia, Fence Houses	Oct. 12, 1901
88 HERRIOTTS, JOSEPH GEORGE, Tasra Colliery, Bhugudih, B.N.R., Bengal, India	April 28, 1900
89 HERRON, EDWARD, 4, Holly Terrace, Stanley, S.O , County Durham	Feb. 15, 1896

		Date of Election and of Transfer.
90	HESLOP, WILLIAM, High Grange, Howden-le-Wear, S.O., County Durham	Oct. 8, 1898
91	HORNSBY, DEMSTER, Choppington Colliery, Scotland Gate, Morpeth	Feb. 12, 1898
92	HUDSON, MARK, 115, Gurney Valley, Bishop Auckland ...	Dec. 9, 1905
93	HUGHES, THOMAS, Fan Terrace, Urpeth Busty, Birtley, S.O., County Durham	Feb. 10, 1906
94	HUMBLE, JOHN NORMAN, Linden House, Beamish, S.O., County Durham	S. Aug. 2, 1902 A. Aug. 5, 1905
95	HUMBLE, WILLIAM HENRY, Seafield House, Risehow, Maryport	Dec. 14, 1907
96	HUNTER, ANDREW, 2, Abbotsford Terrace, South Shields ...	Feb. 13, 1897
97	IMRIE, HENRY MARSHALL, 22, Western Hill, Durham ...	Feb. 14, 1903
98	JEFFERY, ALBERT JOHN, 8, Agents Terrace, Boldon Colliery, S.O., County Durham	April 28, 1900
99	JOBLING, JOHN SWANSTONE, 10, Langley Street, Langley Park, Durham...	Oct. 12, 1907
100	JOHNSON, THOMAS, 3, Granville Terrace, Binchester Blocks, Bishop Auckland	Dec. 9, 1905
101	JOHNSON, WILLIAM, Banks House, Church Street, Durham	Aug. 6, 1892
102	JONES, WALTER, c/o Mrs. Fenwick, The Farm, Wheatley Hill Colliery, Thornley, S.O., County Durham ...	S. Feb. 9, 1901 A. Aug. 1, 1908
103	LASCELLES, WALTER REGINALD, Great Western Colliery, Pontypridd	Feb. 8, 1908
104	LEWISS, EDWARD MIDDLEMASS, 3, Eighth Row, Ashington, Morpeth	Oct. 12, 1907
105	LIDDELL, CHRISTOPHER, Houghton Main Colliery, near Barnsley	S. Dec. 14, 1901 A. Aug. 6, 1904
106	LIGHTLEY, JOHN, Byers Green, Spennymoor	April 25, 1896
107	LOGAN, REGINALD SAMUEL MONCRIEFF, 33, Boyd Terrace, Blucher Pit, Newburn, S.O., Northumberland	S. Feb. 9, 1901 A. Aug. 1, 1903
108	LONGRIDGE, JOHN, Castlecomer, S.O., County Kilkenny ..	Feb. 11, 1905
109	MCCARTHY, MICHAEL DODDS, 63, D Street, Perkinsville, Pelton Fell, S.O., County Durham	Dec. 14, 1901
110	MCDONALD, FRANCIS, 9, Neale Street, Annfield Plain, S.O., County Durham	Oct. 13, 1906
111	MACGREGOR, DONALD, Seghill Colliery, Seghill, Dudley, S.O., Northumberland	S. Feb. 9, 1901 A. Aug. 1, 1908
112	MCGREGOR, JOHN EDWARD, 49, Eden Terrace, Oxhill, Stanley, S.O., County Durham	S. April 4, 1903 A. Aug. 1, 1903
113	MARR, JAMES EDMUND, High Spen, Newcastle-upon-Tyne...	Feb. 8, 1908
114	MARSHALL, JOHN JOSEPH	April 9, 1904
115	MASON, BENJAMIN, Burnopfield Colliery, Burnopfield, S.O., County Durham	April 11, 1891
116	MELVILLE, JOHN THOMAS, 4, Poplar Gardens, Gosforth, Newcastle-upon-Tyne	April 8, 1899
117	MILBURN, EDWIN WALTER, 4, First Row, Ashington, Morpeth	S. Feb. 10, 1900 A. Aug. 5, 1905
118	MILBURN, WILLIAM, Hill House, Ouston, Birtley, S.O., County Durham	June 8, 1895
119	MILBURNE, JOHN ETHERINGTON, East View, Dalton-on-Tees	S. Oct. 14, 1899 A. Aug. 6, 1904
120	MILLER, ALEXANDER, South Greta Colliery, near West Maitland, New South Wales, Australia	Oct. 10, 1903
121	MILLNE, DAVID, 1, Burdon Street, Bedlington, S.O., Northumberland	Aug. 3, 1907
122	MINNS, THOMAS TATE, Jun., Binchester Blocks, Bishop Auckland	S. April 10, 1897 A. Aug. 1, 1903
123	MINTO, GEORGE WILLIAM, Harraton Colliery, Chester-le-Street	Oct. 10, 1891

	Date of Election and of Transfer.
124*Mitchell-Withers, William Charles	S. April 28, 1900 A. Aug. 2, 1902
125 Morland, Thomas, New Herrington, Philadelphia, Fence Houses	Feb. 11, 1899
126 Morson, Farrer William, Glenholm, Crook, S.O., County Durham	Aug. 4, 1900
127 Musgrove, William, Heddon Colliery, Northumberland...	S. June 8, 1895 A. Aug. 1, 1903
128 Nelson, George Catron, Greenhead Terrace, Chopwell Colliery, Ebchester, S.O., County Durham	Feb. 8, 1902
129 Nichols, Henry Herbert, Kibblesworth, Gateshead-upon-Tyne	Aug. 3, 1907
130 Oliver, Ernest Hunter, Denewell Avenue, Low Fell, Gateshead-upon-Tyne	S. Feb. 8, 1902 A. Aug 1, 1908
131 Oswald, George Robert, c/o The Labuan Coal-fields Company, Limited, Borneo. All communications to be sent to E. William Oswald, 14, Victoria Road, Whitehaven	S. June 9, 1900 A. Aug. 3, 1907
132 Owen, William Rowland, The Sangli Gold-mines, Limited, Gadag, Bombay Presidency, India	Feb. 12, 1898
133 Paddon, Neville Blackmore	Dec. 14, 1907
134 Palmer, Meyrick, The Manor House, Medomsley, S.O., County Durham	S. June, 8, 1901 A. Aug. 1, 1908
135 Parrington, Henry Mason, Hill House, Monkwearmouth, Sunderland	S. Feb. 13, 1904 A. Aug. 3, 1907
136 Pattison, Andrew, Greenside, Ryton, S.O., County Durham	Dec. 8, 1906
137 Pattison, Charles Arthur, High Grange, Howden-le-Wear, S.O., County Durham	S. April 13, 1901 A. Aug. 5, 1905
138 Pattison, William, Horsley House, East Stanley, Stanley, S.O., County Durham	Dec. 13, 1902
139 Pearson, John Charlton, Swiss Cottage, Westerhope, Newcastle-upon-Tyne	Feb. 14, 1903
140 Peel, George, Jun., 27, Langley Street, Langley Park, Durham	April 4, 1903
141 Phelps, Charles, c/o Darby and Company, Sandakan, British North Borneo	Aug. 3, 1901
142 Potts, Laurance Wylam, c/o Mrs. Swap, 9, Richmond Terrace, Felling, S.O., County Durham	April 4, 1903
143 Pratt, George Ross, Springwell Colliery, Gateshead-upon-Tyne	June 8, 1895
144 Proctor, Thomas, Woodhorn Colliery, Morpeth	Oct. 13, 1894
145 Pumphrey, Charles Ernest, Greenside House, Ryton, S.O., County Durham	S. Dec. 10, 1904 A. Aug. 4, 1906
146 Ramsay, John Gladstone, Bowburn Colliery, *via* Coxhoe, S.O., County Durham	Dec. 10, 1892
147 Ratcliffe, Robert, 14, Ben Street, Alfreton Road, Nottingham	Aug. 3, 1907
148 Richardson, Benjamin, 29, Westcott Terrace, Deanbank, Ferry Hill	April 7, 1906
149 Richardson, Frank, Lynwood, Richmond Street, Ashton-under-Lyne	S. Oct. 12, 1901 A. Aug. 1, 1908
150 Richardson, Henry, Clara Vale Colliery, Ryton, S.O., County Durham	Dec. 8, 1906
151 Ridley, George Dinning, 16, Gosforth Terrace, South Gosforth, Newcastle-upon-Tyne	Feb. 8, 1890
152 Ridley, Henry Anderson, Burnbrae, Blaydon Burn, Blaydon-upon-Tyne, S.O., County Durham	Dec. 14, 1907
153 Ridley, William, Jun., Mary Pit, Blaydon-upon-Tyne, S.O., County Durham	Dec. 8, 1906
154 Ridpath, Tom R., Medomsley, S.O., County Durham ...	S. June 8, 1901 A. Aug. 4, 1906

		Date of Election and of Transfer.
155	RIVERS, JOHN, Bow Street, Thornley Colliery, Durham ..	Feb. 9, 1895
156	ROBINSON, CHRISTOPHER, Dudley Colliery, Dudley, S.O., Northumberland	April 13, 1907
157	ROBINSON, JOHN WILLIAM, 3, The Terrace, Boldon Colliery, S.O., County Durham	S. April 12, 1902 A. Aug. 5, 1905
158	ROBINSON, STANLEY, Bunker Hill, Fence Houses	S. Oct. 12, 1901 A. Aug. 1, 1908
159	ROCHESTER, WILLIAM, 1, Office Row, Netherton Colliery, Nedderton, Newcastle-upon-Tyne	Dec. 9, 1905
160	ROCHESTER, WILLIAM, Ryton Barmoor, Ryton, S.O., County Durham	Dec. 10, 1898
161	ROCHESTER, WILLIAM SIMM, 3, Victoria Terrace, Hamsterley, Ebchester, S.O., County Durham	Feb. 13, 1904
162	ROGERS, JOHN, Widdrington Colliery, Acklington, S.O., Northumberland	S. April 8, 1899 A. Aug. 4, 1906
163	ROLFE, ROBERT, Falstone Colliery, Falstone, S.O., Northumberland	Dec. 9, 1905
164	ROOSE, HUBERT F. G., Royal School of Mines, South Kensington, London, S.W.	S. Dec. 9, 1899 A. Aug. 3, 1907
165	RUTHERFORD, ROBERT ARCHIBALD, Wellington Terrace, Edmondsley, Durham	Dec. 14, 1907
166	RUTHERFORD, THOMAS EASTON, West Shield Row Colliery, Stanley, S.O., County Durham	S. June 10, 1899 A. Aug. 4, 1906
167	SANER, CHARLES B., Turf Mines, Limited, P.O. Box 5887, Johannesburg, Transvaal	April 10, 1897
168	SCHOLLICK, THOMAS, 13, Model Street, New Seaham, Sunderland	Dec. 12, 1903
169	SCOBIE, ISAAC, Woonona, near Sydney, New South Wales, Australia	Oct. 13, 1906
170	SEED, ALEXANDER, 1, College Terrace, Brandon Colliery, S.O., County Durham	April 4, 1903
171	SEVERS, JONATHAN, Stanley, S.O., County Durham ...	S. June 8, 1895 A. Aug. 4, 1900
172	SHARP, THOMAS, Wilson Terrace, Broughton Moor, Maryport	Dec. 14, 1907
173	SIMPSON, RICHARD CHARLTON, Wellington Terrace, Edmondsley, Durham	Feb. 13, 1904
174	SMITH, ERNEST ARTHUR, 5, Bath Terrace, Seaham Harbour, Sunderland	S. Dec. 9, 1905 A. Aug. 1, 1908
175	SNAITH, JOSEPH, South Pontop Colliery, Annfield Plain, S.O., County Durham	Oct. 12, 1907
176	SNOWDON, THOMAS, Jun., Oakwood, Cockfield, S.O., County Durham	S. June 12, 1897 A. Aug. 3, 1901
177	SOUTHERN, STEPHEN, Heworth Colliery, Felling, S.O., County Durham	S. Dec. 14, 1895 A. Aug. 3, 1901
178	STOBART, THOMAS CARLTON, Ushaw Moor Colliery, Durham	Aug. 2, 1902
179	STOKER, NICHOLAS, South Pelaw Colliery, Chester-le-Street	Feb. 13, 1904
180	STOKOE, JOHN GEORGE, Alston House, Crigglestone, Wakefield	Dec. 9, 1899
181	STRONG, GEORGE ADAMSON, 33, George Street, Birtley, S.O., County Durham	S. Aug. 2, 1902 A. Aug. 1, 1908
182	SWAN, WILLIAM EDWARD, Washington Colliery, Co. Durham	April 9, 1904
183	SWANN, JOSEPH TODD, 6, Victoria Terrace, Throckley, Newburn, S.O., Northumberland	S. Dec. 13, 1902 A. Aug. 4, 1906
184	TATE, ROBERT SIMON, Saint Hilda Colliery, South Shields...	S. Aug. 3, 1901 A. Aug. 4, 1906
185	TAYLOR, HERBERT WILLIAM, El Bote Mine, Zacatecas, Mexico	Aug. 2, 1902
186	THOMPSON, WILLIAM, Stone House, Broughton Moor, Maryport	Dec. 14, 1907

		Date of Election and of Transfer.
187	TURNBULL, WILLIAM, West Holywell, Backworth Colliery, Newcastle-upon-Tyne	Oct. 8, 1904
188	TURNER, GEORGE, Widdrington Colliery, Widdrington, Acklington, S.O., Northumberland	June 8, 1895
189	TWEDDELL, GEORGE, 51, Double Row, Seaton Delaval, S.O., Northumberland	June 8, 1907
190	TWEDDELL, JOHN SMITH, Seaton Delaval Colliery, Northumberland	S. Feb. 13, 1897 A. Aug. 1, 1903
191	WAINWRIGHT, WILLIAM, Heworth Colliery, Felling, S.O., County Durham	April 2, 1898
192	WALKER, JOSEPH NOEL, 33, Sherburn Terrace, Consett, S.O., County Durham	S. Aug. 6, 1904 A. Aug. 1, 1908
193	WALTON, ARTHUR JOHN, Bettisfield Colliery, Bagillt, S.O., Flintshire	S. Feb. 12, 1898 A. Aug. 1, 1903
194	WALTON, HARRY, Durham Road, Consett, S.O., County Durham	Dec. 10, 1904
195	WALTON, ISAAC, Dovenby, Cockermouth	Dec. 14, 1907
196	WARDLE, ROBERT, Edgewell Terrace, Prudhoe, Ovingham, S.O., Northumberland	April 13, 1907
197	WELSH, ARTHUR, Red House, Tunstall Village, near Sunderland	S. Aug. 1, 1896 A. Aug. 1, 1903
198	WHINN, JOHN, High Spen, Newcastle-upon-Tyne	Feb. 8, 1908
199	WHITFIELD, THOMAS CUTHBERT, Trimdon Grange Colliery, County Durham	Oct. 8, 1904
200	WIDDAS, FRANK, 99, West Chilton Terrace, Ferry Hill ...	Dec. 8, 1900
201	WIDOWFIELD, JOHN GILBERT, Wellington Terrace, Edmondsley, Durham	Dec. 14, 1907
202	WILD, ROBERT POWLEY, c/o R. H. Moore, St. Day, Scorrier, S.O., Cornwall	S. Dec. 8, 1906 A. Aug. 1, 1908
203	WILKINSON, MAURICE HEWSON, c/o Mackenzie and Company, Limited, Chungking, West China, *via* Siberia, Pekin and Hankow	Dec. 12, 1903
204	WILSON, CHRISTOPHER, 6, Beaconsfield Street, Birtley, S.O., County Durham	Feb. 11, 1905
205	WILSON, HUGH, Bajupanee Collieries, Pench Valley P.O., Chindwara District, Central Provinces, India	Feb. 13. 1904
206	WOOD, GEORGE, Dudley Colliery, Dudley, S.O., Northumberland	April 13, 1907
207	WRAITH, ALFRED OSBORN, 73, Lyons Terrace, Hetton-le-Hole, S.O., County Durham	S. June 9, 1900 A. Aug. 1, 1908
208	YIELDER, HUGH LISHMAN, 14, Moor View, Ryton, S.O., County Durham	April 7, 1906
209	YOUNG, GEORGE ELLIS, Kimblesworth Colliery, Chester-le-Street	S. Aug. 3, 1901 A. Aug. 5, 1905

STUDENTS (Stud.I.M.E.).

		Date of Election.
1	AVERY, WILLIAM ERNEST, Ravensworth Colliery Office, Low Fell, Gateshead-upon-Tyne	June 8, 1907
2	BELL, JOHN VALENTINE, 226, Old Farm, Ouston, Chester-le-Street	Dec. 14, 1907
3	BROOKS, DOUGLAS ROY, 83, Victoria Road, Jarrow	Dec. 14, 1907
4	BROWN, JOHN, Central Pench Coal Company, Limited, Pench Valley P.O., District Chindwara, C.P., India	June 8, 1907
5	BRYDON, ANDREW DEMPSTER, Millburn, Darlington	Dec. 8, 1906
6	CALLAND, WILLIAM, Hedley Hope Collieries, Tow Law, S.O., County Durham	April 7, 1906

Date of Election.

7 Coxon, Samuel Bailey, Prior House, Corbridge, S.O., Northumberland ... ... Oct. 12, 1907

8 Dakers, Edgar Walton, Tudhoe Colliery, Spennymoor ... Dec. 14, 1907
9 Daniell, Henry Edmund Blackburne, 8, Ashfield Terrace, Ryton, S.O., County Durham ... ... Aug. 3, 1907
10 Douglas, Albert Edward, Beethoven House, Horden, Castle Eden, S.O., County Durham ... ... Aug. 1, 1903

11 Earnshaw, Oscar, Kiln Bank House, Amble, Acklington, S.O., Northumberland ... ... Feb. 8, 1908

12 Fowler, Albert Ernest, Usworth Villa, Washington Station, S.O., County Durham ... ... Oct. 12, 1907

13 Grace, William Grace, Hall Garth Hall, Winlaton, Blaydon-upon-Tyne, S.O., County Durham ... ... Feb. 9, 1907
14 Graham, William, Jun., Solway House, Moresby, Whitehaven Oct. 13, 1906

15 Hawkins, John Bridges Bailey, Staganhoe Park, Welwyn ... Dec. 13, 1902
16 Hedley, Rowland Frank Hutton, Langholme, Roker, Sunderland ... ... April 4, 1903
17 Hepburn, Henry, Greenhead Terrace, Chopwell, Ebchester, S.O., County Durham ... ... Oct. 12, 1907
18 Herdman, Fred., 7, Chatsworth Parade, Low Fell, Gateshead-upon-Tyne ... ... Dec. 14, 1907
19 Heslop, Wardle, Wyncote, Holywell Avenue, Monkseaton, Whitley Bay, S.O., Northumberland ... ... Dec. 10, 1904
20 Hudspeth, Henry Moore, c/o John William Hudspeth, Willington, S.O., County Durham ... ... Oct. 12, 1907
21 Huggup, Ralph, 1, Bentinck Place, Newcastle-upon-Tyne ... Feb. 10, 1906
22 Hunter, Herbert Stanley, Blakelaw, Kenton, Newcastle-upon-Tyne ... ... Feb. 9, 1907
23 Hutton, Allan Robinson Bowes, Bentley Colliery, near Doncaster ... ... April 8, 1905

24 Kirkup, Ernest Hodgson, Peases West Collieries, Crook, S.O., County Durham ... ... April 13, 1907

25 Lawson, Richard Forster, Daisy Hill, Edmondsley, Durham ... Feb. 13, 1904
26 Liddell, Henry Norman John, Prudhoe House, Prudhoe, Ovingham, S.O., Northumberland ... ... June 10, 1905
27 Lister, John Alfred, Linden House, Carlton Terrace, Spennymoor ... ... Dec. 8, 1906

28 Maughan, Thomas, Tudhoe Colliery Office, Spennymoor ... Dec. 14, 1907
29 Muse, Thomas John, Jun., Cornsay Colliery, Durham ... ... Dec. 8, 1906

30 Nable, Feliciano, 17, Hazelwood Avenue, Jesmond, Newcastle-upon-Tyne ... ... Dec. 9, 1905
31 Nicholson, George Thompson, Dene House, Scotswood, S.O., Northumberland ... ... Dec. 10, 1904

32 Palmer, Harry, The Manor House, Medomsley, S.O., County Durham ... ... June 14, 1902

33 Ritson, John Anthony Sydney, Burnhope Colliery, Lanchester, Durham ... ... Aug. 4, 1906

34 Sharp, Charles Gordon, Riding Mill, S.O., Northumberland... Feb. 10, 1906
35 Simpson, Joseph, Wheatley Hill Colliery Office, Thornley, S.O., County Durham ... ... June 10, 1905
36 Slater, Thomas Edward, Blaydon Burn Colliery, Blaydon-upon-Tyne, S.O., County Durham ... ... April 13, 1907

Date of Election.

37 SOUTHERN, CHARLES, Heworth Colliery, Felling, S.O., County Durham ... ... June 10, 1903

38 THIRLWELL, THOMAS A., 18, Lynwood Avenue, Bentinck Road, Newcastle-upon-Tyne ... ... Dec. 13, 1902
39 THOMAS, ROBERT CLARK, Houghton Colliery, Houghton-le-Spring, S.O., County Durham ... ... Aug. 3, 1907
40 THOMPSON, GEORGE HERON DINSDALE, Dinsdale Vale, Windsor Avenue, Waterloo, Blyth ... ... Feb. 14, 1903
41 THORNTON, FRANK, Cornsay Colliery, Durham ... ... Feb. 8, 1902
42 TURNBULL, JOHN JAMES, Jun., 60, Beaconsfield Street, Blyth ... Feb. 8, 1908

43 WATSON, THOMAS, Jun., Rosebank, Darlington ... ... June 8, 1907
44 WATTS, HUBERT, Cleveland House, North Shields ... ... June 8, 1907
45 WEEKS, FRANCIS MATHWIN, Eastwood Collieries, near Nottingham ... ... Feb. 10, 1906
46 WELCH, WILLIAM HALL, 49, Mitchell Street, Birtley, S.O., County Durham ... ... Feb. 10, 1906
47 WILKINSON, RALPH PERCY, 51, Railway Terrace, New Herrington, Fence Houses ... ... Dec. 9, 1905
48 WRAITH, CHARLES OSBORN, Thornley Colliery Office, Thornley, S.O., County Durham ... ... June 10, 1905

SUBSCRIBERS.

1 OWNERS OF ASHINGTON COLLIERY, Newcastle-upon-Tyne.
2 BIRTLEY IRON COMPANY (3), Birtley, S.O., County Durham.
3 THE BROKEN HILL PROPRIETARY COMPANY, LIMITED, 3, Great Winchester Street, London, E.C.
4 BRUNNER, MOND AND COMPANY, LIMITED, Northwich.
5 The Most Honourable the MARQUESS OF BUTE, Bute Estate Offices, Aberdare.
6 THE CHARLAW AND SACRISTON COLLIERIES COMPANY, LIMITED, 34, Grey Street, Newcastle-upon-Tyne.
7 COWPEN COAL COMPANY, LIMITED (2), F, King Street, Newcastle-upon-Tyne.
8 The Honourable LORD NINIAN EDWARD CRICHTON-STUART, House of Falkland, Falkland, S.O., Fifeshire.
9 DOMINION COAL COMPANY, LIMITED, Glace Bay, Nova Scotia.
10 The Right Honourable the EARL OF DURHAM (2), Lambton Offices, Fence Houses.
11 The Right Honourable the EARL OF ELLESMERE (2), Bridgewater Offices, Walkden, Manchester. *Transactions* sent to Jno. Henry V. Hart-Davis, Bridgewater Offices, Walkden, Manchester.
12 ELSWICK COAL COMPANY, LIMITED, Newcastle-upon-Tyne.
13 D. H. and G. HAGGIE, Wearmouth Patent Rope Works, Sunderland.
14 HARTON COAL COMPANY, LIMITED (3), Harton Collieries, South Shields.
15 HETTON COAL COMPANY (5), Fence Houses.
16 JAMES JOICEY AND COMPANY, LIMITED (2), Newcastle-upon-Tyne.
17 LAMBTON COLLIERIES, LIMITED (2), E, Queen Street, Newcastle-upon-Tyne.
18 The Most Honourable the MARQUESS OF LONDONDERRY (5), c/o Vincent Charles Stuart Wortley Corbett, Londonderry Offices, Seaham Harbour.
19 MAVOR AND COULSON, LIMITED, 47, Broad Street, Mile-End, Glasgow.
20 NORTH BRANCEPETH COAL COMPANY, LIMITED, Crown Street Chambers, Darlington.
21 OWNERS OF NORTH HETTON COLLIERY (3), Fence Houses.
22 OSBECK AND COMPANY, Pit Timber Merchants, Newcastle-upon-Tyne.
23 RAND MINES, LIMITED, The Corner House, Johannesburg, Transvaal.
24 RYHOPE COAL COMPANY (2), Ryhope Colliery, Sunderland.
25 OWNERS OF SEGHILL COLLIERY, Seghill, Dudley, S.O., Northumberland.
26 SIEMENS BROTHERS AND COMPANY, LIMITED, 39, Collingwood Buildings, Newcastle-upon-Tyne.

27 Société Houillère de Liévin (Pas-de-Calais), Liévin, Pas-de-Calais, France.
28 Owners of South Hetton and Murton Collieries (2), 50, John Street, Sunderland.
29 Owners of Stella Colliery, Hedgefield, Blaydon-upon-Tyne, S.O., County Durham.
30 Owners of Throckley Colliery, Newcastle-upon-Tyne.
31 Owners of Victoria Garesfield Colliery, Victoria Garesfield Colliery, Lintz Green, County Durham. *Transactions* sent to H. Peile, Priestman's Collieries, Limited, Milburn House, Newcastle-upon-Tyne.
32 Owners of Wearmouth Colliery (2), Sunderland.
33 Westport Coal Company, Limited (2), Dunedin, New Zealand.

ENUMERATION.

	August 1, 1908.
Honorary Members	21
Members	942
Associate Members	105
Associates	209
Students	48
Subscribers	33
Total	1,358

Members are desired to communicate all changes of address, or any corrections or omissions in the list of names, to the Secretary.

CHARTER OF THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

FOUNDED 1852.

INCORPORATED NOVEMBER 28TH, 1876.

Victoria, by the Grace of God, of the United Kingdom of Great Britain and Ireland, Queen, Defender of the Faith, TO ALL TO WHOM THESE PRESENTS SHALL COME, GREETING :

WHEREAS it has been represented to us that NICHOLAS WOOD, of Hetton, in the County of Durham, Esquire (since deceased) ; THOMAS EMERSON FORSTER, of Newcastle-upon-Tyne, Esquire (since deceased) ; SIR GEORGE ELLIOT, Baronet (then George Elliot, Esquire), of Houghton Hall, in the said County of Durham, and EDWARD FENWICK BOYD, of Moor House, in the said County of Durham, Esquire, and others of our loving subjects, did, in the year one thousand eight hundred and fifty-two, form themselves into a Society, which is known by the name of THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS, having for its objects the Prevention of Accidents in Mines and the Advancement of the Sciences of Mining and Engineering generally, of which Society LINDSAY WOOD, of Southill, Chester-le-Street, in the County of Durham, Esquire, is the present President. AND WHEREAS it has been further represented to us that the Society was not constituted for gain, and that neither its projectors nor Members derive nor have derived pecuniary profit from its prosperity ; that it has during its existence of a period of nearly a quarter of a century steadily devoted itself to the preservation of human life and the safer development of mineral property ; that it has contributed substantially and beneficially to the prosperity of the country and the welfare and happiness of the working members of the community ; that the Society has since its establishment diligently pursued its aforesaid objects, and in so doing has made costly experiments and researches with a view to the saving of life by improvements in the ventilation of mines, by ascertaining the conditions under which the safety lamp may be relied on for security ; that the experiments conducted by the Society have related to accidents in mines of every description, and have not been limited to those proceeding from explosions ; that the various modes of getting coal, whether by mechanical appliances or otherwise, have received careful and continuous attention, while the improvements in the mode of working and hauling belowground, the machinery employed for preventing the disastrous falls of roof underground, and the prevention of spontaneous combustion in seams of coal as well as in cargoes, and the providing additional security for the miners in ascending and descending the pits, the improvements in the cages used for this purpose, and in the safeguards against what is technically known as "overwinding," have been most successful in lessening the dangers of mining, and in preserving human life ; that the Society has held meetings at stated

periods, at which the results of the said experiments and researches have been considered and discussed, and has published a series of Transactions, filling many volumes, and forming in itself a highly valuable Library of scientific reference, by which the same have been made known to the public, and has formed a Library of Scientific Works and Collections of Models and Apparatus, and that distinguished persons in foreign countries have availed themselves of the facilities afforded by the Society for communicating important scientific and practical discoveries, and thus a useful interchange of valuable information has been effected; that in particular, with regard to ventilation, the experiments and researches of the Society, which have involved much pecuniary outlay and personal labour, and the details of which are recorded in the successive volumes of the Society's Transactions, have led to large and important advances in the practical knowledge of that subject, and that the Society's researches have tended largely to increase the security of life; that the Members of the Society exceed 800 in number, and include a large proportion of the leading Mining Engineers in the United Kingdom. And whereas in order to secure the property of the Society, and to extend its useful operations, and to give it a more permanent establishment among the Scientific Institutions of our Kingdom, we have been besought to grant to the said Lindsay Wood, and other the present Members of the Society, and to those who shall hereafter become Members thereof, our Royal Charter of Incorporation. Now know ye that we, being desirous of encouraging a design so laudable and salutary, of our especial grace, certain knowledge, and mere motion, have willed, granted, and declared, and do, by these presents, for us, our heirs, and successors, will, grant, and declare, that the said Lindsay Wood, and such others of our loving subjects as are now Members of the said Society, and such others as shall from time to time hereafter become Members thereof, according to such Bye-laws as shall be made as hereinafter mentioned, and their successors, shall for ever hereafter be, by virtue of these presents, one body, politic and corporate, by the name of "The North of England Institute of Mining and Mechanical Engineers," and by the name aforesaid shall have perpetual succession and a Common Seal, with full power and authority to alter, vary, break, and renew the same at their discretion, and by the same name to sue and be sued, implead and be impleaded, answer and be answered unto, in every Court of us, our heirs and successors, and be for ever able and capable in the law to purchase, acquire, receive, possess, hold, and enjoy to them and their successors any goods and chattels whatsoever, and also be able and capable in the law (notwithstanding the statutes of mortmain) to purchase, acquire, possess, hold and enjoy to them and their successors a hall or house, and any such other lands, tenements, or hereditaments whatsoever, as they may deem requisite for the purposes of the Society, the yearly value of which, including the site of the said hall or house, shall not exceed in the whole the sum of three thousand pounds, computing the same respectively at the rack rent which might have been had or gotten for the same respectively at the time of the purchase or acquisition thereof. And we do hereby grant our especial license and authority unto all and every person and persons and bodies politic and corporate, otherwise competent, to grant, sell, alien, convey or devise in mortmain unto and to the use of the said Society and their successors, any lands, tenements, or hereditaments not exceeding

with the lands, tenements or hereditaments so purchased or previously acquired, such annual value as aforesaid, and also any moneys, stocks, securities, and other personal estate to be laid out and disposed of in the purchase of any lands, tenements or hereditaments not exceeding the like annual value. And we further will, grant, and declare, that the said Society shall have full power and authority, from time to time, to sell, grant, demise, exchange and dispose of absolutely, or by way of mortgage, or otherwise, any of the lands, tenements, hereditaments and possessions, wherein they have any estate or interest, or which they shall acquire as aforesaid, but that no sale, mortgage, or other disposition of any lands, tenements, or hereditaments of the Society shall be made, except with the approbation and concurrence of a General Meeting. And our will and pleasure is, and we further grant and declare that for the better rule and government of the Society, and the direction and management of the concerns thereof, there shall be a Council of the Society, to be appointed from among the Members thereof, and to include the President and the Vice-Presidents, and such other office-bearers or past office-bearers as may be directed by such Bye-laws as hereinafter mentioned, but so that the Council, including all *ex-officio* Members thereof, shall consist of not more than forty or less than twelve Members, and that the Vice-Presidents shall be not more than six or less than two in number. And we do hereby further will and declare that the said Lindsay Wood shall be the first President of the Society, and the persons now being the Vice-Presidents, and the Treasurer and Secretary, shall be the first Vice-Presidents, and the first Treasurer and Secretary, and the persons now being the Members of the Council shall be the first Members of the Council of the Society, and that they respectively shall continue such until the first election shall be made at a General Meeting in pursuance of these presents. And we do hereby further will and declare that, subject to the powers by these presents vested in the General Meetings of the Society, the Council shall have the management of the Society, and of the income and property thereof, including the appointment of officers and servants, the definition of their duties, and the removal of any of such officers and servants, and generally may do all such acts and deeds as they shall deem necessary or fitting to be done, in order to carry into full operation and effect the objects and purposes of the Society, but so always that the same be not inconsistent with, or repugnant to, any of the provisions of this our Charter, or the Laws of our Realm, or any Bye-law of the Society in force for the time being. And we do further will and declare that at any General Meeting of the Society, it shall be lawful for the Society, subject as hereinafter mentioned, to make such Bye-laws as to them shall seem necessary or proper for the regulation and good government of the Society, and of the Members and affairs thereof, and generally for carrying the objects of the Society into full and complete effect, and particularly (and without its being intended hereby to prejudice the foregoing generality), to make Bye-laws for all or any of the purposes hereinafter mentioned, that is to say: for fixing the number of Vice-Presidents, and the number of Members of which the Council shall consist, and the manner of electing the President and Vice-Presidents, and other Members of the Council, and the period of their continuance in office, and the manner and time of supplying any vacancy therein; and for regulating the times at which General Meetings of the Society and Meetings of the Council shall be held,

and for convening the same and regulating the proceedings thereat, and for regulating the manner of admitting persons to be Members of the Society, and of removing or expelling Members from the Society, and for imposing reasonable fines or penalties for non-performance of any such Bye-laws, or for disobedience thereto, and from time to time to annul, alter, or change any such Bye-laws, so always that all Bye-laws to be made as aforesaid be not repugnant to these presents, or to any of the laws of our Realm. AND WE DO FURTHER will and declare that the present Rules and Regulations of the Society, so far as they are not inconsistent with these presents, shall continue in force, and be deemed the Bye-laws of the Society until the same shall be altered by a General Meeting, PROVIDED ALWAYS that the present Rules and Regulations of the Society and any future Bye-laws of the Society so to be made as aforesaid shall have no force or effect whatsoever until the same shall have been approved in writing by our Secretary of State for the Home Department. IN WITNESS WHEREOF WE HAVE CAUSED THESE OUR LETTERS TO BE MADE PATENT.

Witness Ourself at our Palace, at Westminster, the 28th day of November, in the fortieth year of our reign.

By Her Majesty's Command.

CARDEW.

Great Seal of the United Kingdom.

BYE-LAWS.

I.—CONSTITUTION.

1.—The North of England Institute of Mining and Mechanical Engineers shall consist of Members, Associate Members and Honorary Members. The Institute shall in addition comprise Associates and Students.

2.—The Officers of the Institute, other than the Treasurer and the Secretary, shall be elected from the Members and Associate Members, and shall consist of a President, six Vice-Presidents, and eighteen Councillors, who, with the Treasurer and the Secretary (if Members of the Institute) shall constitute the Council.

All Past-Presidents shall be *ex-officio* Members of the Council, so long as they continue Members or Associate Members of the Institute; and Vice-Presidents who have not been re-elected or have become ineligible from having held office for three consecutive years, shall be *ex-officio* Members of the Council for the following year.

II.—QUALIFICATIONS OF MEMBERS, ASSOCIATE MEMBERS, HONORARY MEMBERS, ASSOCIATES AND STUDENTS.

3.—MEMBERS.—Every candidate for admission into the class of Members, or for transfer into that class, shall come within the following conditions:—He shall be more than twenty-three years of age, have been regularly educated as a Mining or Mechanical Engineer, or in some other

branch of Engineering, according to the usual routine of pupilage, and have had subsequent employment for at least two years in some responsible situation as an Engineer, or if he has not undergone the usual routine of pupilage, he must have been employed or have practised as an Engineer for at least five years. This class shall also comprise every person who was an Ordinary Member, Life Member, or Student on the first of August, 1877.

4.—Associate Members shall be persons connected with or interested in Mining or Engineering, and not practising as Mining or Mechanical Engineers, or in some other branch of Engineering.

5.—Honorary Members shall be persons who have distinguished themselves by their literary or scientific attainments, or who have made important communications to the Society.

6.—Associates shall be persons acting as under-viewers, under-managers, or in other subordinate positions in mines, or employed in analogous positions in other branches of Engineering.

7.—Students shall be persons who are qualifying themselves for the profession of Mining or Mechanical Engineering, or other branch of Engineering, and such persons may continue Students until they attain the age of twenty-five years.

III.—Election and Expulsion of Members.

8.—Any person desirous of becoming a Member, an Associate Member, an Associate or a Student, shall be proposed according to the proper Form in the Appendix, in which Form the name, usual residence, and qualifications of the candidate shall be distinctly specified. The Form must be signed by the proposer and at least two other Members or Associate Members, certifying a personal knowledge of the candidate, who shall himself sign the undertaking contained therein.

Any person qualified to become an Honorary Member shall be proposed according to the proper Form in the Appendix, in which Form the name, usual residence, and qualifications of the candidate shall be distinctly stated. This Form must be signed by the proposer and at least five other Members or Associate Members, certifying a personal knowledge of the candidate, who shall himself sign the undertaking contained therein, and the Council shall have the power of defining the time during which, and the circumstances under which the candidate shall be an Honorary Member.

Any Associate or Student desirous of becoming a Member, shall be proposed and recommended according to the proper Form in the Appendix, in which Form the name, usual residence, and qualifications of the candidate shall be distinctly specified. This Form must be signed by the proposer and at least two other Members or Associate Members, certifying a personal knowledge of the candidate, who shall himself sign the undertaking contained therein, and the proposal shall then be treated in the manner hereinafter described.

Every proposal shall be delivered to the Secretary, and by him submitted to the next meeting of the Council, who, on approving the qualifications, shall determine if the candidate is to be presented for ballot, and if it is so determined, the Chairman of the Council shall sign such proposal. The same shall be read at the next Ordinary General Meeting, and afterwards be exhibited in the Institute's Hall until the following Ordinary General Meeting, when the candidate shall be balloted for.

A Student may become an Associate at any time after attaining the age of twenty-one years.

9.—The balloting shall be conducted in the following manner:—Each Member or Associate Member attending the meeting, at which a ballot is to take place, shall be supplied (on demand) with a list of the names of the persons to be balloted for, according to the proper Form in the Appendix, and shall strike out the names of such candidates as he desires shall not be elected, and return the list to the scrutineers appointed by the presiding Chairman for the purpose, and such scrutineers shall examine the lists so returned, and inform the meeting what elections have been made. No candidate shall be elected unless he secures the votes of two-thirds of the Members and Associate Members voting.

10.—Notice of election shall be sent to every person within one week after his election, according to the proper Form in the Appendix, and the person elected shall send the amount of his annual subscription, or life composition, within four months from the date of such election, which otherwise shall become void.

11.—Every Member having signed a declaration according to the proper Form in the Appendix, and having likewise made the proper payment, shall receive a certificate of his election, according to the proper Form in the Appendix.

12.—Any Member, Associate Member, Associate or Student elected at any meeting between the Annual Meetings shall be entitled to all Transactions issued in the Institute's year, so soon as he has signed and returned a declaration according to the proper Form in the Appendix, and paid his subscripton.

13.—The Transactions of the Institute shall not be forwarded to those whose subscriptions are in arrear on the first of November in each year.

14.—Any person whose subscription is more than one year in arrear shall be reported to the Council, who shall direct application to be made for it, according to the proper Form in the Appendix, and in the event of its continuing one month in arrear after such application, the Council shall have the power, after remonstrance by letter to his last recorded address in the books of the Society, according to the proper Form in the Appendix, of declaring that the defaulter has ceased to be a Member.

15.—In case the expulsion of any person shall be judged expedient by ten or more Members or Associate Members, and they think fit to draw up and sign a proposal requiring such expulsion, the same being delivered to the Secretary, shall be by him laid before the next meeting of the Council for consideration. If the Council, after due inquiry, do not find reason to concur in the proposal, no entry thereof shall be made in any minutes, nor shall any public discussion thereon be permitted, unless by requisition signed by one-half of the Members or Associate Members of the Institute; but if the Council do find good reason for the proposed expulsion, they shall direct the Secretary to address a letter, according to the proper Form in the Appendix, to the person proposed to be expelled, advising him to withdraw from the Institute. If that advice be followed, no entry on the minutes nor any public discussion on the subject shall be permitted; but if that advice be not followed, nor an explanation given which is satisfactory to the Council, they shall call a General Meeting for the purpose of deciding on the question of expulsion; and if a majority of the Members and Associate Members present at such meeting (provided

the number so present be not less than forty) vote that such person be expelled, the Chairman of that meeting shall declare the same accordingly, and the Secretary shall communicate the same to the person, according to the proper Form in the Appendix.

IV.—Subscriptions.

16.—The annual subscription of each Member and Associate Member shall be £2 2s., of each Associate and Student £1 5s., payable in advance, and shall be considered due on election, and afterwards on the first Saturday in August of each year.

17.—Any Member, Associate Member, Associate or Student, may, at any time, compound for all future subscriptions by a payment in accordance with the following scale:—

Under 30	years of age,	the sum of	£31
Over 30	„	„	„	27
„ 40	„	„	„	24
„ 50	„	„	„	21
„ 60	„	„	„	17

or on such other conditions as the Council may, in writing, accept. Every person so compounding shall be a Member, Associate Member, Associate or Student for life, as the case may be. Any Associate Member, Associate or Student so compounding who may afterwards be qualified to become a Member, may do so, by election in the manner described in Bye-law 8. All compositions shall be deemed capital money of the Institute.

18.—In case any Member, Associate Member or Associate, who has been long distinguished in his professional career, becomes unable, from ill-health, advanced age, or other sufficient cause, to carry on a lucrative practice, the Council may, on the report of a Sub-Committee appointed by them for that purpose, if they find good reason for the remission of the annual subscription, so remit it. They may also remit any arrears which are due from a Member, or they may accept from him a collection of books, or drawings, or models, or other contributions, in lieu of the composition mentioned in Bye-law 17, and may thereupon release him from any or all future subscriptions, and permit him to resume his former rank in the Institute.

19.—Owners of Collieries, Engineers, Manufacturers, Railway Companies, and Employers of labour generally, may subscribe annually to the funds of the Institute, and each such subscriber of £2 2s. annually shall be entitled to tickets to admit two persons to the rooms, library, meetings, lectures, and public proceedings of the Society; and for every additional £2 2s., subscribed annually, two other persons shall be admissible; and each such subscriber shall also be entitled for each £2 2s. subscription to have a copy of the Transactions of the Institute sent to him.

V.—Election of Officers.

20.—The President, Vice-Presidents, and Councillors shall be elected at the Annual Meeting in August (except in cases of vacancies) and shall be eligible for re-election to any office, with the exception of any President who may have held office for the two immediately preceding years, or Vice-President who may have held office for the three immediately preceding years, and such six Councillors as may have attended the fewest

Council Meetings during the past year, and when any such attendances are equal, the Council shall decide between them ; but any such Member or Associate Member shall be eligible for re-election after being one year out of office.

Any Retiring Vice-President or Councillor who may be ineligible for re-election shall nevertheless be eligible to any other office.

21.—Each Member and Associate Member shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members and Associate Members suitable to fill the offices of President, Vice-Presidents, and Members of Council for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members and Associate Members as they deem suitable for the various offices. Such lists shall comprise the names of not less than thirty persons. The list so prepared by the Council shall be submitted to the Ordinary General Meeting in June, and shall be the balloting list for the annual election in August. (See proper Form in the Appendix.) A copy of this list shall be posted at least seven days previous to the Annual Meeting to every Member and Associate Member, who may erase any name or names from the list, and substitute the name or names of any other Member or Associate Member eligible for each respective office ; but the number of names on the list, after such erasure or substitution, must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the scrutineers. The votes for any Member who may not be elected President or Vice-Presidents shall count for them as Members of the Council, but in no case shall he receive more than one vote from each voter. The Chairman shall appoint four scrutineers, who shall receive the balloting papers, and, after making the necessary scrutiny, destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the meeting, so as to be received before the appointment of the scrutineers for the election of Officers.

22.—In case of the decease, expulsion, or resignation of any Officer or Officers, the Council, if they deem it requisite that the vacancy shall be filled up, shall present to the next Ordinary General Meeting a List of persons whom they nominate as suitable for the vacant office or offices, and a new Officer or Officers shall be elected at the first succeeding Ordinary General Meeting.

23.—The Treasurer and the Secretary shall be appointed by the Council, and shall be removable by the Council, subject to appeal to a General Meeting. One and the same person may hold both these offices.

VI.—Duties of the Officers and Council.

24.—The President shall take the chair at all meetings of the Institute, the Council, and Committees, at which he is present (he being *ex-officio* a member of all), and shall regulate and keep order in the proceedings.

25.—In the absence of the President, it shall be the duty of the senior Vice-President present to preside at the meetings of the Institute, to keep order, and to regulate the proceedings. In case of the absence of

the President and of all the Vice-Presidents, the meeting may elect any Member of Council, or in case of their absence, any Member or Associate Member present, to take the chair at the Meeting.

26.—At Meetings of the Council, five shall be a quorum. The minutes of the Council's proceedings shall be at all times open to the inspection of the Members and Associate Members.

27.—The Treasurer and the Secretary shall act under the direction and control of the Council, by which body their duties shall from time to time be defined.

28.—The Council may appoint Committees for the purpose of transacting any particular business, or of investigating any specific subject connected with the objects of the Institute. Such Committees shall make a report to the Council, who shall act thereon, and make use thereof as they see occasion.

VII.—Communications and Memoirs.

29.—All papers shall be sent for the approval of the Council at least twenty-one days before a General Meeting, and after approval, shall be read before the Institute. The Council shall also direct whether any paper read before the Institute shall be printed in the Transactions, and immediate notice shall be given to the writer whether it is to be printed or not.

30.—The copyright of all papers communicated to, and accepted for printing by the Council, and printed within twelve months, shall become vested in the Institute, and such communications shall not be published for sale or otherwise, without the written permission of the Council.

31.—Twenty copies of each paper printed by the Institute shall be presented to the author for private use.

32.—All proofs of reports of discussions, forwarded to any person for correction, must be returned to the Secretary within seven days from the date of their receipt, otherwise they will be considered correct and be printed off.

33.—The Institute is not, as a body, responsible for the statements and opinions advanced in the papers which may be read, nor in the discussions which may take place at the meetings of the Institute.

VIII.—Meetings of the Institute.

34.—An Ordinary General Meeting shall be held on the first Saturday of every month (except January and July) at two o'clock, unless otherwise determined by the Council; and the Ordinary General Meeting in the month of August shall be the Annual Meeting, at which a report of the proceedings, and an abstract of the accounts of the previous year, shall be presented by the Council.

35.—All donations to the Institute shall be acknowledged in the Annual Report of the Council.

36.—A Special General Meeting shall be called whenever the Council may think fit, and also on a requisition to the Council, signed by ten or more Members or Associate Members. The business of a Special Meeting shall be confined to that specified in the notice convening it.

37.—The Members, Associate Members, Honorary Members, Associates and Students, shall have notice of, and the privilege to attend, all Ordinary General Meetings and Special Meetings.

38.—Every question, not otherwise provided for, which shall come before any meeting, shall be decided by the votes of the majority of the Members and Associate Members then present.

39.—Invitations shall be forwarded to any person whose presence at the discussions the Council may think advisable, and strangers so invited shall be permitted to take part in the proceedings but not to vote.

Any Member or Associate Meember shall have power to introduce two strangers (see proper Form in the Appendix) to any General Meeting, but they shall not take part in the proceedings except by permission of the meeting.

IX.—Property of the Institute.

40.—The Funds of the Society shall be deposited in the hands of the Treasurer, and shall be disbursed or invested by him according to the direction of the Council.

41.—The Institute Hall and Reading Room shall be open to the Members, Associate Members, Honorary Members, Associates and Students on every week day, from 10 a.m. to 5 p.m., except on such special day or days when the Council shall think it expedient to close the rooms and suspend the circulation of Books. Books shall be issued according to regulations from time to time approved by the Council.

42.—No duplicate copies of any portion of the Transactions shall be issued to any Member, Associate Member, Associate or Student, unless by order from the Council.

X.—Alteration of Bye-laws.

43.—No alteration shall be made in the Bye-laws of the Institute, except at the Annual Meeting, or at a Special Meeting for that purpose, and the particulars of every such alteration shall be announced at a previous Ordinary Meeting, and inserted in its minutes, and shall be exhibited in the room of the Institute fourteen days previous to such Annual or Special Meeting, and such Meeting shall have power to adopt any modification of such proposed alteration of the Bye-laws.

I hereby approve the foregoing Bye-laws.

M. W. RIDLEY,

One of Her Majesty's Principal Secretaries of State.

Whitehall,

23rd September, 1898.

APPENDIX TO THE BYE-LAWS.

FORM A, Honorary Member.

A. B. [Christian Name, Surname, Occupation, and Address in full], being a person who has distinguished .....self

[*Here specify distinctly the qualifications of the Candidate, according to the spirit of Bye-law 5.*]

On the above grounds, I propose ..... to the Council, from *personal knowledge*, as a proper person to be elected an Honorary Member of the Institute.

Signed.....Member or Associate Member.

Dated this.....day of..... .....190 .

We, the undersigned, concur in the above recommendation, from *personal knowledge*, being convinced that A. B. is in every respect a proper person to be elected an Honorary Member of the Institute.

.....
.....
.....
.....
.....
} Five Members or Associate Members.

[*Undertaking to be signed by the Candidate.*]

I, the undersigned, do hereby promise that, in the event of my election, I will be governed by the Royal Charter and Bye-laws of the Institute for the time being, or as they may hereafter be altered, amended, or enlarged under the powers of the said Royal Charter; and that I will promote the objects of the Institute as far as may be in my power, and will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can; provided that whenever I shall signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) cease to belong to the Institute.

Signed.....

Dated this.....day of.....190 .

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as an Honorary Member of The North of England Institute of Mining and Mechanical Engineers.

Signed.....Chairman.

Nominated at the Ordinary General Meeting ...190 .
Passed by the Council .....190 .
Elected at the Ordinary General Meeting .....190 .

FORM B, MEMBER.

A. B. [Christian Name, Surname, Occupation, and Address in full], born on the.....day of.....18 , being desirous of belonging to The North of England Institute of Mining and Mechanical Engineers, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, because—

[*Here specify distinctly the qualifications of the Candidate, according to the spirit of Bye-law 3.*]

On the above grounds, I propose him to the Council as a proper person to belong to the Institute.

Signed.....Member or Associate Member.

Dated this.....day of.....190 .

We, the undersigned, concur in the above recommendation, from *personal knowledge*, being convinced that A. B. is in every respect a proper person to belong to the Institute.

.....
.....
} Two Members or Associate Members.

[*Undertaking to be signed by the Candidate.*]

I, the undersigned, do hereby promise that, in the event of my election, I will be governed by the Royal Charter and Bye-laws of the Institute for the time being, or as they may hereafter be altered, amended, or enlarged under the powers of the said Royal Charter; and that I will promote the objects of the Institute as far as may be in my power, and will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can; provided that whenever I shall

signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) cease to belong to the Institute.

Signed.....

Dated this.....day of.....190 .

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as a Member of The North of England Institute of Mining and Mechanical Engineers.

Signed.....Chairman.

Nominated at the Ordinary General Meeting ...190 .
Passed by the Council .....190 .
Elected at the Ordinary General Meeting .....190 . Age,.....years.

FORM C, Associate Member, Associate or Student.

A. B. [Christian Name, Surname, Occupation, and Address in full], born on the.....day of.....18 , being desirous of belonging to The North of England Institute of Mining and Mechanical Engineers, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, and propose him to the Council as a proper person to belong to the Institute.

Signed.....Member or Associate Member.

Dated this.....day of.....190 .

We, the undersigned, concur in the above recommendation, from *personal knowledge*, being convinced that A. B. is in every respect a proper person to belong to the Institute.

..... } Two Members
..... } or Associate Members.

[*Undertaking to be signed by the Candidate.*]

I, the undersigned, do hereby promise that, in the event of my election, I will be governed by the Royal Charter and Bye-laws of the Institute for the time being, or as they may hereafter be altered, amended, or enlarged under the powers of the said Royal Charter; and that I will promote the objects of the Institute as far as may be in my power, and will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can; provided that whenever I shall signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) cease to belong to the Institute.

Signed.....

Dated this.....day of.....190 .

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as a.....of The North of England Institute of Mining and Mechanical Engineers.

Signed.....Chairman.

Nominated at the Ordinary General Meeting ...190 .
Passed by the Council .....190 .
Elected at the Ordinary General Meeting .....190 . Age,.....years.

FORM D, TRANSFER TO MEMBER OR ASSOCIATE MEMBER.

A. B. [Christian Name, Surname, Occupation, and Address in full], born on the.....day of.....18 , at present a..... of The North of England Institute of Mining and Mechanical Engineers, being desirous of becoming a.....Member of the said Institute, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, because—

[*Here specify distinctly the qualifications of the Candidate, according to the spirit of Bye-laws 3 or 4.*]

On the above grounds, I propose him to the Council as a proper person to be admitted a.....Member.

Signed..... .....Member or Associate Member.

Dated this.....day of.....190 .

We, the undersigned, concur in the above recommendation, from *personal knowledge*, being convinced that A. B. is in every respect a proper person to be admitted a.....Member.

..... } Two Members
..... } or Associate Members.

[*Undertaking to be signed by the Candidate.*]

I, the undersigned, do hereby promise that, in the event of my election, I will be governed by the Royal Charter and Bye-laws of the Institute for the time being, or as they may hereafter be altered, amended, or enlarged under the powers of the said Royal Charter; and that I will promote the objects of the Institute as far as may be in my power, and will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can; provided that whenever I shall signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) cease to belong to the Institute.

Signed.....

Dated this.....day of.....190 .

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as a.....Member of The North of England Institute of Mining and Mechanical Engineers.

Signed.....Chairman.

Nominated at the Ordinary General Meeting ...190 .
Passed by the Council .....190 .
Elected at the Ordinary General Meeting .....190 . Age,.....years.

FORM E.

List of the names of persons to be balloted for at the Ordinary General Meeting on.....the.....day of.....190 .

MEMBERS:—

.....

ASSOCIATE MEMBERS:—

.....

HONORARY MEMBERS:—

.....

ASSOCIATES:—

.....

STUDENTS:—

.....

Strike out the names of such persons as you desire should *not* be elected, and hand the list to the Chairman.

FORM F.

SIR,—I beg leave to inform you that on the.....day of..... you were elected a.....of The North of England Institute of Mining and Mechanical Engineers. In conformity with its Bye-laws your election cannot be confirmed until your first annual subscription be paid, the amount of which is £....., and, at your option, a life-composition in accordance with the following scale:—

Under 30 years of age	...	...	...	...	...	£31
Over 30 ,, ,,	...	...	...	...	...	27
,, 40 ,, ,,	...	...	...	...	...	24
,, 50 ,, ,,	...	...	...	...	...	21
,, 60 ,, ,,	...	...	...	...	...	17

If the subscription is not received within four months from the present date, the election will become void under Bye-law 10.

All annual subscriptions are due on the first Saturday in August of each year.

I am, sir, yours faithfully,

Dated.....190 . .....Secretary.

FORM G.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.
Founded 1852. Incorporated by Royal Charter, A.D. 1876.

These are to certify that A. B. [Christian Name, Surname, Occupation, and Address in full] was elected a Member of The North of England Institute of Mining and Mechanical Engineers, at an Ordinary General Meeting held on the.....day of..... .. ..190 .

Witness our hands and seal this.....day of.....190 .

(Seal.) .....President.
.....Secretary.

FORM H.

SIR,—I am directed by the Council of The North of England Institute of Mining and Mechanical Engineers to draw your attention to Bye-law 14, and to remind you that the sum of £.....of your annual subscriptions to the funds of the Institute remains unpaid, and that you are in consequence in arrear of subscription. I am also directed to request that you will cause the same to be paid without further delay, otherwise the Council will be under the necessity of exercising their discretion as to using the power vested in them by the Article above referred to.

I am, sir, yours faithfully,

.....Secretary.

Dated.....190 .

FORM I.

SIR,—I am directed by the Council of The North of England Institute of Mining and Mechanical Engineers to inform you that, in consequence of non-payment of your arrears of subscription, and in pursuance of Bye-law 14, the Council have determined that unless payment of the amount £..... is made previous to the.....day of.....next, they will proceed to declare that you have ceased to be a Member of the Institute.

But, notwithstanding this declaration, you will remain liable for payment of the arrears due from you.

I am, sir, yours faithfully,

.....Secretary.

Dated.....190 .

FORM J.

SIR,—I am directed by the Council of The North of England Institute of Mining and Mechanical Engineers to inform you that, upon mature consideration of a proposal which has been laid before them relative to you, they feel it their duty to advise you to withdraw from the Institute, or otherwise they will be obliged to act in accordance with Bye-law 15.

I am, sir, yours faithfully,

.....Secretary.

Dated.....190 .

FORM K.

SIR,—It is my duty to inform you that, under a resolution passed at a Special General Meeting of The North of England Institute of Mining and Mechanical Engineers, held on the.....day of.....190 , according to the provisions of Bye-law 15, you have ceased to be a..... of the Institute.

I am, sir, yours faithfully,

.....Secretary.

Dated.....190 .

FORM L, BALLOTING LIST.

Ballot to take place at the Annual Meeting on.....190.....at Two o'clock, p.m.

The names of persons for whom the voter does *not* vote must be erased, and the names of other persons eligible for re-election may be inserted in their place, provided the number remaining on the list does not exceed the number of persons to be elected.

PRESIDENT—Not more than ONE NAME to be returned, or the vote will be lost.

_____ President for the current year eligible for re-election.*

_____ } New Nominations.*

VICE-PRESIDENTS—Not more than SIX NAMES to be returned, or the vote will be lost.

The Votes for any Member who may not be elected President or Vice-Presidents shall count for them as Members of the Council, but in no case shall he receive more than one vote from each voter.

_____ } Vice-Presidents for the current year eligible for re-election.

_____ } New Nominations.

COUNCIL Not more than EIGHTEEN NAMES to be returned, or the vote will be lost.

_____ } Members of the Council for the current year eligible for re-election.

_____ } New Nominations.

Any list returned with a greater number of Names than ONE PRESIDENT, SIX VICE-PRESIDENTS, or EIGHTEEN COUNCILLORS, Will be rejected by the Scrutineers as informal, and the Votes will consequently be lost.

* To be inserted when necessary.

Ex-Officio Members of the Council for the ensuing year :—

_____ } Past-Presidents.

_____ } Retiring Vice-Presidents.

Bye-law 21.

Each Member and Associate Member shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members and Associate Members suitable to fill the offices of President, Vice-Presidents, and Members of Council for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members and Associate Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty persons. The list so prepared by the Council shall be submitted to the Ordinary General Meeting in June, and shall be the balloting list for the annual election in August. (See proper Form in the Appendix.) A copy of this list shall be posted at least seven days previous to the Annual Meeting to every Member and Associate Member, who may erase any name or names from the list, and substitute the name or names of any other Member or Associate Member eligible for each respective office ; but the number of names on the list, after such erasure or substitution, must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the scrutineers. The votes for any member who may not be elected President or Vice-Presidents shall count for them as Members of the Council, but in no case shall he receive more than one vote from each voter. The Chairman shall appoint four scrutineers, who shall receive the balloting papers, and, after making the necessary scrutiny, destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the meeting, so as to be received before the appointment of the scrutineers for the election of Officers.

Names substituted for any of the above are to be written in the blank spaces opposite those they are intended to supersede.

The following Members are ineligible from causes specified in Bye-law 20 :—

As President .....

As Vice-Presidents .....

As Councillors .....

FORM M.

Admit .....

of .....

to the Ordinary General Meeting on Saturday, the.....

(Signature of Member, Associate Member, Associate or Student).....

The Chair to be taken at Two o'clock p.m.

I undertake to abide by the Bye-laws of The North of England Institute of Mining and Mechanical Engineers, and not to aid in any unauthorised publication of the Proceedings.

(Signature of Visitor).....

Not transferable.

INDEX TO VOL. LVIII.

Explanations.

The — at the beginning of a line denotes the repetition of a word; and in the case of Names, it includes both the Christian Name and the Surname; or, in the case of the name of any Firm, Association or Institution, the full name of such Firm, etc.

Discussions are printed in *italics*.

"Abs." signifies Abstracts of Foreign Papers at the end of the Proceedings.

"App." signifies Annual Report of the Council, etc., at the end of the Volume.

A.

Absorption, heat, circulation and, in steam boilers, 259.
Accidents, boiler-, France, 1905, abs. 45.
—, Germany, Prussia, collieries, electrical installations, 1905, abs. 45.
—, —, —, —, — —, 1906, abs. 47.
Accounts, 8; app. ii., xi.
Address, presidential, J. H. Merivale, 15.
Aerolith rescue-apparatus, 179, 184.
Africa, Cameroons, mining developments, abs. 2.
—, German East, mining developments, abs. 3.
—, — —, uranium-ores, abs. 5.
—, — South-west, mining developments, abs. 3.
—, Manicaland, rare minerals, abs. 8.
—, Rhodesia, auriferous deposits, abs. 1.
—, —, stanniferous deposits, abs. 1.
—, Togoland, mining developments, abs. 2.
—, Transvaal, auriferous deposits, abs. 1.
—, —, stanniferous deposits, abs. 1.
Aguillon, L., working of native sulphur in Sicily and in Louisiana, abs. 26.
Ahlburg, —, metalliferous mines of Styria, Carinthia and Carniola, Austria, abs. 59.
Air, coal-dust and, experiments illustrative of inflammability of mixtures of, 71.
Annual general meeting, 1.
— report of council, 2; app. ii., v.
— — — finance committee, 6; app. ii., x.
Armstrong, William, *deficiency in nomenclature of mineral deposits*, 109.
Arsenical ore-deposits, Germany, Silesia, Reichenstein, abs. 87.
Ashworth, James, *report on circumstances attending explosion of fire-damp and coal-dust at Urpeth colliery*, 40.
Asphalt, Austria-Hungary, Hungary, abs. 66.
Associate members, election, 14, 70, 106, 127, 244.
— —, list, app. ii., xlvi.
Associates, election, 14, 70, 106, 127, 244.
—, list, app. ii., l.
Atkinson, J. B., *deficiency in nomenclature of mineral deposits*, 110.
—, *demonstration of rescue-apparatus, Felling, August 31st, 1907*, 187, 190, 193, 194.
—, *experiments illustrative of inflammability of mixtures of coal-dust and air*, 77.
—, *flinty chert, hornstone, etc.*, 201, 202, 247.
—, *locking hook for sinking purposes*, 153.
—, *mining and engineering in America and Canada*, 124.
—, report on circumstances attending explosion of fire-damp and coal-dust at Urpeth colliery, December 17th, 1906.—Discussion, 39.
Auriferous deposits, Africa, Rhodesia, abs. 1.
— —, —, Transvaal, abs. 1.
— —, Italy, Piedmont, Brusson, abs. 89.

Auriferous deposits, Madagascar, abs. 6.
— rocks, Austria-Hungary, Transylvania, abs. 71.
— sands, gold in, determination, abs. 20.
Austin, Lawrence, demonstration of rescue-apparatus, Felling, August 31st, 1907, 178.—Discussion, 185.
Austria-Hungary, Austria, lower, Payerbach-Reichenau district, iron-ores, abs. 68.
— —, Bosnia, fahlore deposits, abs. 64.
— —, —, mercury-ore deposits, abs. 64.
— —, —, north-eastern, Bjelina, brown coals, abs. 62.
Austria-Hungary, Carinthia, metalliferous mines, abs. 59.
— —, Carniola, metalliferous mines, abs. 59.
— —, Herzegovina, fahlore deposits, abs. 64.
— —, —, mercury-ore deposits, abs. 64.
— —, Hungary, asphalt, abs. 66.
— —, —, Karács-Czebe gold-mines, abs. 22.
— —, —, petroleum, abs. 66.
— —, Moravia, Rossitz, coal-field, abs. 69.
— —, Styria, metalliferous mines, abs. 59.
— —, Transylvania, auriferous rocks, abs. 71.

B.

Bärtling, R., iron-ore deposits of northern Sweden, abs. 94.
Basalts, Færöe islands, native copper in, abs. 72.
Beck, R., stanniferous and auriferous deposits of Transvaal and Rhodesia, abs. 1.
Bedson, P. Phillips, *report on circumstances attending explosion of fire-damp and coal-dust at Urpeth colliery*, 53.
Bedson, P. Phillips, and Henry Widdas, experiments illustrative of inflammability of mixtures of coal-dust and air: part ii., 71.—Discussion, 77.
Bentley colliery, sinking, 168.
Berthelot, Daniel, precious gems and radio-activity, abs. 59.
Beyling, —, dynamite-explosion at Zappendorf bore-hole, Germany, abs. 33.
Biggs, J. T., *occurrence and commercial uses of fluorspar*, 231.
Blackett, W. C., *circulation and heat absorption in steam boilers*, 270, 271.
—, *demonstration of rescue-apparatus, Felling, August 31st, 1907*, 188, 193, 194.
—, *experiments illustrative of inflammability of mixtures of coal-dust and air*, 77, 78.
—, *report on circumstances attending explosion of fire-damp and coal-dust at Urpeth colliery*, 49.
Bodifée, —, iron- and manganese-ore deposits of Oberrosbach, Germany, abs. 84.
Boiler-accidents, France, 1905, abs. 45.
Boilers, steam, circulation and heat absorption in, 259.
Bordas, F., precious gems and radio-activity, abs. 58.
Bore-hole, Germany, Saxony, Zappendorf, dynamite explosion, abs. 33.
Borussia colliery, Germany, Westphalia, Dortmund, fire, abs. 42.
Bradley, Benjamin L., *occurrence and commercial uses of fluorspar*, 233, 244.
Brazil, diamantiferous deposits, abs. 10.
—, native copper in diabases, abs. 9.
—, palladium, abs. 11.
—, platinum, abs. 11.
Brough, Bennett H., *flinty chert, hornstone, etc.*, 201.
Brown, E. O. Forster, *mining and engineering in America and Canada*, 157.
Brown, Martin Walton, *annual report of council*, 5.
—, death, 104.
—, memoir, 171.
Brown coal, Austria-Hungary, Bosnia, north-eastern, Bjelina, abs. 62.
— — deposits, Germany, Hesse-Nassau, Hoher Westerwald, abs. 75.
— — mines, Germany, Saxony, Prussia, use of excavators, abs. 31.
Bulman, H. F., memoir of Martin Walton Brown, 171.
Burns, David, *occurrence and commercial uses of fluorspar*, 244.
Bye-laws, app. ii., lxiii.

C.

Canada, engineering, 111, 157.
—, mining, 111, 157.
—, Rocky mountains, coal-fields, abs. 13.
—, — —, lignite-fields, abs. 13.
Cargo Fleet steel- and iron-works, 237.
Cast-iron tubbing: what is its rational formula, 127, 167, 248.
— — — for deep shafts, strength of, 80, 133, 167.

Charter, app. ii., lx.
Chemical theory, petroleum, origin, abs. 53.
Chert, flinty, hornstone, etc., 199, 247.
Chile, tourmaline-bearing cobalt-deposits, abs. 12.
China, Shantung, Kiaochau, mining developments, abs. 4.
Choke-damp disaster, Germany, Upper Silesia, König colliery, abs. 44.
Chrysolite, precious, St. John's island, Red Sea, abs. 15.
Circulation and heat absorption in steam boilers, 259.
Clarke, T. B. A., *demonstration of rescue-apparatus, Felling, August 31st, 1907*, 185.
Clive, Robert, and J. W. Fryar, sinking of Bentley colliery.—Discussion, 168.
Coal, brown, Austria-Hungary, Bosnia, north-eastern, Bjelina, abs. 62.
—, —, Germany, Hesse-Nassau, Hoher Westerwald, abs. 75.
—, France, eastern, Franche-Comté, search for, abs. 73.
Coal-dust and air, experiments illustrative of inflammability of mixtures of, 71.
— — explosion, Germany, Rhenish Prussia, Saarbrücken, Reden colliery, abs. 40.
Coal-fields, Austria-Hungary, Bosnia, north-eastern, Bjelina, abs. 62.
— —, — —, Moravia, Rossitz, abs. 69.
— —, Canada, Rocky mountains, abs. 13.
— —, China, Shantung, Kiaochau, abs. 4.
— —, Germany, Erzgebirge region, possible new, abs. 79.
— —, —, Rhenish Prussia, Saarbrücken, government collieries, abs. 80.
Coal-fields, Germany, Silesia, upper, eastern border, lower carboniferous, abs. 85.
— —, United States of America, Rocky mountains, abs. 13.
Cobalt-deposits, tourmaline-bearing, Chile, abs. 12.
Collins, J. H., *occurrence and commercial uses of fluorspar*, 232.
Colomba, Luigi, auriferous deposits of Brusson, Piedmont, abs. 89.
Committees, 1908-1909, app. ii., xvi.
Concrete, ferro-, Dunston-upon-Tyne, 61.
Copiapite, identification with jánosite, abs. 16.
—, sulphate-of-iron mineral, abs. 16.
Copper, native, in basalts, Færöe islands, abs. 72.
—, —, — diabases, Brazil, abs. 9.
Coquimbite, sulphate-of-iron mineral, abs. 16.
Cornu, F., native copper in Færöe basalts, abs. 72.
Cornu, F., and M. Lazarevič, cupriferous deposits of Bor, Servia, abs. 94.
Coulson, Frank, *cast-iron tubbing: what is its rational formula*, 127.
—, *demonstration of rescue-apparatus, Felling, August 31st, 1907*, 191.
—, *locking hook for sinking purposes*, 56, 151.
—, *sinking of Bentley colliery*, 168, 170.
Council, annual report, 2; app. ii., v.
— of The Institution of Mining Engineers, election of representatives on, 7.
Couyat, J., rare minerals from Manicaland, South Africa, abs. 8.
Cremer, R., Wolf-Bohres electric safety-lamp, 59.—Discussion, 60.
Cupriferous deposits, Servia, Bor, abs. 94.

D.

Death, Martin Walton Brown, 104.
Deep shafts, tubbing, cast-iron, strength, 80, 133, 167.
Desdemona salt-mine, Germany, Hanover, explosion, abs. 35.
Diabases, Brazilian, native copper in, abs. 9.
— and pegmatites as matrices of diamond, abs. 56.
Diamantiferous deposits, Brazil, abs. 10.
Diamonds, diabases and pegmatites as matrices, abs. 56.
Dickinson, Joseph, *report on circumstances attending explosion of fire-damp and coal-dust at Urpeth colliery*, 40.
Douglas, Thomas, *annual report of council*, 5.
—, portraits of past-presidents and secretaries, 242.
—, *presidential address*, 38.
Dræger rescue-apparatus, 179, 184.
Dunston-upon-Tyne, ferro-concrete work, 61.
Dynamite explosion, bore-hole, Germany, Saxony, Zappendorf, abs. 33.

E.

Egglestone, W. M., *flinty chert, hornstone, etc.*, 202, 247.
—, occurrence and commercial uses of fluorspar, 204.—Discussion, 231, 244.
Einer, —, explosion at Reden colliery, near Saarbrücken, Germany, abs. 40.
Election of members, 14, 69, 105, 126, 166, 243.

Election of officers, 1.
— — representatives on council of The Institution of Mining Engineers, 7.
Electric pump, Tyne Main colliery, 66.
— safety-lamp, Wolf-Bohres, 59.
Electrical installations, Germany, Prussia, collieries, accidents, 1905, abs. 45.
— —, —, —, —, —, 1906, abs. 47.
Engineering, Canada, 111, 157.
—, United States of America, 111, 157.
Escarpelle mines, No. 5 pit, water-stowage, simple method, 159.
Excavators, Germany, Saxony, Prussia, brown-coal mines, use of, abs. 31.
Excursion meetings, 61, 66, 237.
Explosion, dynamite, bore-hole, Germany, Saxony, Zappendorf, abs. 33.
—, fire-damp, France, Pas-de-Calais, Liévin collieries, abs. 35.
—, Germany, Hanover, Desdemona salt-mine, abs. 35.
—, —, Rhenish Prussia, Saarbrücken, Reden colliery, abs. 40.
Explosions, collieries, Germany, Prussia, 1905, abs. 37.

F.

Færöe islands, native copper in basalts, abs. 72.
Fahlore deposits, Austria-Hungary, Bosnia, abs. 64.
— —, — —, Herzegovina, abs. 64.
Felling, demonstration of rescue-apparatus, 178.
Ferro-concrete work, Dunston-upon-Tyne, 61.
Field, E. R., *deficiency in nomenclature of mineral deposits*, 155.
Finance committee, annual report, 6; app. ii., x.
Finland, Pitkäranta, ore-deposits, abs. 91.
Fire, Germany, Westphalia, Dortmund, Borussia colliery, abs. 42.
Fire-damp explosion, France, Pas-de-Calais, Liévin collieries, abs. 35.
— — —, Germany, Rhenish Prussia, Saarbrücken, Reden colliery, abs. 40.
— — indicator, Gréhant, abs. 34.
Fissure-veins, occurrence of kimberlite in, abs. 18.
Fleuss-Siebe-Gorman rescue-apparatus, 180, 184.
Flinty chert, hornstone, etc., 199, 247.
Fluhr, Robert, iron-ore deposits of Württemberg, Germany, abs. 82.
Fluorspar, occurrence and commercial uses, 204, 244.
Formation of kaolin, abs. 57.
Formula, rational, cast-iron tubbing, 127, 167, 248.
Forster, T. E., death of M. Walton Brown, 104.
—, *deficiency in nomenclature of mineral deposits*, 109.
—, *demonstration of rescue-apparatus, Felling, August 31st, 1907*, 194.
—, *experiments illustrative of inflammability of mixtures of coal-dust and air*, 78.
—, portraits of past-presidents and secretaries, 241.
Fournier, Albert, determination of gold in auriferous sands, abs. 20.
Fournier, Eugène, search for coal in Franche-Comté, eastern France, abs. 73.
France, boiler-accidents, 1905, abs. 45.
—, Britanny, Morbihan, Coatquidan, iron-ores, abs. 74.
—, eastern, Franche-Comté, coal, search for, abs. 73.
—, Escarpelle mines, No. 5 pit, water-stowage, simple method, 159.
—, Normandy, lower, ordovician iron-ores, abs. 74.
—, Pas-de-Calais, Liévin collieries, fire-damp explosion, abs. 35.
Freise, F., brown-coal deposits of Hoher Westerwald, Germany, abs. 77.
Frigidite, variety of tetrahedrite, abs. 17.
Fryar, J. W., and Robert Clive, sinking of Bentley colliery.—Discussion, 168.
Futers, T. C., *locking hook for sinking purposes*, 153.

G.

Gäbert, C., possible new coal-fields in Erzgebirge region, Germany, abs. 79.
Galloway, William, *cast-iron tubbing: what is its rational formula*, 131.
—, *strength of cast-iron tubbing for deep shafts*, 136.
Garforth, W. E., awarded G. C. Greenwell medal, 13.
Gascuel, L., auriferous deposits of Madagascar, abs. 6.
Gems, precious, and radio-activity, abs. 58.
General meetings, 1, 61, 66, 69, 104, 126, 166, 237, 241.
Geothermic degree, values of, underground temperatures, abs. 48.
German colonies, mining developments, abs. 2.

Germany, Erzgebirge region, possible new coal-fields, abs. 79.
—, Hanover, Desdemona salt-mine, explosion, abs. 35.
—, Hesse, Oberrosbach, iron-ore deposits, abs. 84.
—, —, —, manganese-ore deposits, abs. 84.
—, Hesse-Nassau, Hoher Westerwald, brown-coal deposits, abs. 75.
—, Prussia, collieries, electrical installations, accidents, 1905, abs. 45.
—, —, —, — —, —, 1906, abs. 47.
—, —, —, explosions, 1905, abs. 37.
—, Rhenish Prussia, Saarbrücken, coal-field, government collieries, abs. 80.
—, — —, —, Reden colliery, explosion, abs. 40.
—, Saxony, Prussia, brown-coal mines, use of excavators, abs. 31.
—, —, Zappendorf, bore-hole, dynamite explosion, abs. 33.
Germany, Siegerland, iron-ores, age, abs. 83.
—, Silesia, Reichenstein, arsenical ore-deposits, abs. 87.
—, —, upper, coal-field, eastern border, lower carboniferous, abs. 85.
—, —, —, König colliery, choke-damp disaster, abs. 44.
—, Westphalia, Dortmund, Borussia colliery, fire, abs. 42.
—, Württemberg, iron-ore deposits, abs. 82.
Glasser, E., nepouite, a new nickeliferous mineral, abs. 19.
Gold in auriferous sands, determination, abs. 20.
Gold-mines, Austria-Hungary, Hungary, Karács-Czebe, abs. 22.
— —, Mexico, Arzate, abs. 28.
Greenwell, G. C., medal, presentations of, 13.
Créhant fire-damp indicator, abs. 34.

H.

Halbaum, H. W. G., cast-iron tubbing: what is its rational formula. —Discussion, 127, 167, 248.
—, *deficiency in nomenclature of mineral deposits*, 153, 156.
—, *demonstration of rescue-apparatus, Felling, August 31st, 1907*, 195.
—, *strength of cast-iron tubbing for deep shafts*, 138, 167.
Harker, Thomas, flinty chert, hornstone, etc., 199.—Discussion, 201, 247.
Heat absorption, circulation and, in steam boilers, 259.
Heinhold, Max, origin of pyropissite or paraffin-coal, abs. 51.
Heurteau, Ch. E., ordovician iron-ores of lower Normandy, abs. 74.
Hidden, W. E., and C. H. Warren, yttrocrasite and paratacamite: two new minerals, abs. 20.
Honorary members, election, 243.
— —, list, app. ii., xviii.
Hook, locking, for sinking purposes, 56, 151.
Hornstone, flinty chert, etc., 199, 247.
Hughes, H. W., *locking hook for sinking purposes*, 56.
Hussak, Eugen, diamantiferous deposits in Brazil, abs. 10.
—, native copper in Brazilian diabases, abs. 9.
—, palladium and platinum in Brazil, abs. 11.

I.

Inflammability of mixtures of coal-dust and air, experiments illustrative of, 71.
Institution of Mining Engineers, election of representatives on council of, 7.
Iron, sulphate-of-, minerals, abs. 16.
Iron-ore deposits, Germany, Hesse, Oberrosbach, abs. 84.
— — —, —, Württemberg, abs. 82.
— — —, Sweden, northern, abs. 94.
Iron-ores, Austria-Hungary, Austria, lower, Payerbach-Reichenau district, abs. 68.
— —, France, Britanny, Morbihan, Coatquidan, abs. 74.
— —, Germany, Siegerland, age, abs. 83.
— —, ordovician, France, Normandy, lower, abs. 74.
Iron-works, Cargo Fleet, 237.
Italy, Piedmont, Brusson, auriferous deposits, abs. 89.

J.

Jánosite, identification with copiapite, abs. 16.

K.

Kalitzky, K., geology of Grozny oil-field, Russia, abs. 89.
Kaolin, formation, abs. 57.
Karács-Czebe gold-mines, Austria-Hungary, Hungary, abs. 22.
Katzer, Friedrich, brown coals of

Bjelina, north-eastern Bosnia, abs. 62.
Katzer, Friedrich, fahlore and mercury-ore deposits of Bosnia and Herzegovina, abs. 64.
Kerforne, F., Coatquidan iron-ores, Britanny, abs. 74.
Kertchenite, a new mineral, abs. 19.
Kimberlite, occurrence in fissure-veins, abs. 18.
Kirkup, J. P., *flinty chert, hornstone, etc.*, 247.
König colliery, Germany, Upper Silesia, choke-damp disaster, abs. 44.
Königsberger, Joh., underground temperatures: values of geothermic degree, abs. 48.
Krasnopolsky, A., mining district of Neviansk, Russia, abs. 93.
Krusch, P., distribution of metalliferous ores in depth, abs. 49.

L.

Lazarevič, M., and F. Cornu, cupriferous deposits of Bor, Servia, abs. 94.
Leach, C. C., *circulation and heat absorption in steam boilers*, 269, 270.
Liddell, J. M., *presidential address*, 38.
Liévin collieries, France, Pas-de-Calais, fire-damp explosion, abs. 35.
Lignite-fields, Canada, Rocky mountains, abs. 13.
— —, United States of America, Rocky mountains, abs. 13.
Locking hook for sinking purposes, 56, 151.
Lotz, H., age of Siegerland iron-ores, Germany, abs. 83.
Louis, Henry, deficiency in nomenclature of mineral deposits, 108.—Discussion, 109, 153.
—, *demonstration of rescue-apparatus, Felling, August 31st, 1907*, 195.
—, *experiments illustrative of inflammability of mixtures of coal-dust and air*, 77.
—, *flinty chert, hornstone, etc.*, 201, 202.
—, locking hook for sinking purposes, 56.—Discussion, 56, 151.
—, *mining and engineering in America and Canada*, 125.
—, *sinking of Bentley colliery*, 169.
—, *strength of cast-iron tubbing for deep shafts*, 133.

M.

Madagascar, auriferous deposits, abs. 6.
Manasse, Ernesto, frigidite, a variety of tetrahedrite, abs. 17.
Manganese-ore deposits, Germany, Hesse, Oberrosbach, abs. 84.
Manganese-ores, abs. 21.
Marckwald, W., uranium-ores from German East Africa, abs. 5.
Matrices of diamond, diabases and pegmatites, abs. 56.
Members, election, 14, 69, 105, 126, 166, 243.
—, list, app. ii., xix.
Memoir, Martin Walton Brown, 171.
Mercury-ore deposits, Austria-Hungary, Bosnia, abs. 64.
— — —, — —, Herzegovina, abs. 64.
Merensky, Hans, diabases and pegmatites as matrices of diamond, abs. 56.
Merivale, John H., *annual report of finance committee*, 7.
—, *circulation and heat absorption in steam boilers*, 272.
—, death of M. Walton Brown, 104, 105.
—, *deficiency in nomenclature of mineral deposits*, 110.
—, *demonstration of rescue-apparatus, Felling, August 31st, 1907*, 197.
Merivale, John H., *experiments illustrative of inflammability of mixtures of coal-dust and air*, 79.
—, *locking hook for sinking purposes*, 153.
—, *mining and engineering in America and Canada*, 125.
—, portraits of past-presidents and secretaries, 242.
—, presidential address, 15.—Discussion, 38.
—, *strength of cast-iron tubbing for deep shafts*, 103, 151.
Metalliferous mines, Austria-Hungary, Carinthia, abs. 59.
— —, — —, Carniola, abs. 59.
— —, — —, Styria, abs. 59.
— —, Mexico, Zacualpan, abs. 29.
— ores, distribution, in depth, abs. 49.
Mexico, Arzate, gold-mines, abs. 28.
—, —, silver-mines, abs. 28.
—, Zacualpan, metalliferous mines, abs. 29.
Meyer, G. A., awarded G. C. Greenwell medal, 13.
Michael, R., lower carboniferous of eastern border of Upper Silesian coal-field, abs. 85.
Michel, L., precious chrysolite of St. John's island, Red Sea, abs. 15.

Mineral deposits, nomenclature of, deficiency in, 108, 153.
— industry, Russian Central Asia, abs. 24.
Minerals, rare, Africa, Manicaland, abs. 8.
Mining, Canada, 111, 157.
—, United States of America, 111, 157.
Morrow, John, strength of cast-iron tubbing for deep shafts, 80.—Discussion, 103, 133, 167.

N.

Nepouite, new nickeliferous mineral, abs. 19.
New Guinea, Kaiser Wilhelm's Land, mining developments, abs. 4.
Nickeliferous mineral, new, nepouite, abs. 19.
Nomenclature of mineral deposits, deficiency in, 108, 153.

O.

O'Donahue, T. A., *strength of cast-iron tubbing for deep shafts*, 144.
Officers, election, 1.
—, 1908-1909, app. ii., xvii.
Oil-field, Russia, Grozny, geology, abs. 89.
Okorn, Friedrich, Government collieries in Saare district, Germany, abs. 80.
Oliver, Thomas, *demonstration of rescue-apparatus, Felling, August 31st, 1907*, 196.
Ordovician iron-ores, France, Normandy, lower, abs. 74.
Ore-deposits, Africa, Cameroons, abs. 2.
——, —, German East, abs. 3.
——, —, — South-west, abs. 3, 5.
——, —, Manicaland, abs. 8.
——, —, Rhodesia, abs. 1.
——, —, Togoland, abs. 2.
——, —, Transvaal, abs. 1.
——, Austria-Hungary, Austria, lower, Payerbach-Reichenau district, abs. 68.
——, ——, Bosnia, abs. 64.
——, ——, Carinthia, abs. 59.
——, ——, Carniola, abs. 59.
Ore-deposits, Austria-Hungary, Herzegovina, abs. 64.
——, ——, Styria, abs. 59.
——, ——, Transylvania, abs. 71.
——, Brazil, abs. 10.
——, China, Shantung, Kiaochau, abs. 4.
——, cobalt, Chile, abs. 12.
——, copper, Brazil, abs. 9.
——, Færöe islands, abs. 72.
——, Finland, Pitkäranta, abs. 91.
——, France, Britanny, Morbihan, Coatquidan, abs. 74.
——, —, Normandy, lower, abs. 74.
——, Germany, Hesse, Oberrosbach, abs. 84.
——, —, Silesia, Reichenstein, arsenical, abs. 87.
——, —, Württemberg, abs. 82.
——, Italy, Piedmont, Brusson, abs. 89.
——, New Guinea, Kaiser Wilhelms Land, abs. 4.
——, Russia, Neviansk, abs. 93.
——, Servia, Bor, abs. 94.
——, Sweden, northern, abs. 94.
Ores, metalliferous, distribution, in depth, abs. 49.

P.

Padbury, John, *demonstration of rescue-apparatus, Felling, August 31st, 1907*, 186.
Pálfy, M. von, auriferous rocks of Transylvania, abs. 71.
Palladium, Brazil, abs. 11.
Papp, Karl von, Karács-Czebe gold-mines, Hungary, abs. 22.
Paraffin-coal or pyropissite, origin, abs. 51.
Paratacamite, a new mineral, abs. 20.
Paravivianite, a new mineral, abs. 19.
Past-presidents, portraits, 241.
Patrons, list, app. ii., xviii.
Pegmatites and diabases as matrices of diamond, abs. 56.
Perry, John, *strength of cast-iron tubbing for deep shafts*, 136.
Pervinquière, L., chemical theory of origin of petroleum, abs. 53.
Petroleum, Austria-Hungary, Hungary, abs. 66.
—, origin, abs. 55.
—, —, chemical theory, abs. 53.
Pilkington, C., *strength of cast-iron tubbing for deep shafts*, 135.
Platinum, Brazil, abs. 11.
Popoff, S., paravivianite and kertchenite, two new minerals, abs. 19.
Portraits of past-presidents and secretaries, 241.
Posewitz, Theodor, petroleum and asphalt in Hungary, abs. 66.
Precious gems and radio-activity, abs. 58.
Presidential address, J. H. Merivale, 15.
Presidents, past-, portraits, 241.
Pump, electric, Tyne Main colliery, 66.
Pyropissite or paraffin-coal, origin, abs. 51.

R.

Radio-activity, precious gems and, abs. 58.
Red Sea, St. John's island, precious chrysolite, abs. 15.
Reden colliery, Germany, Rhenish Prussia, Saarbrücken, explosion, abs. 40.
Redlich, Karl, iron-ores of Payerbach-Reichenau district, Lower Austria, abs. 68.
Redmayne, R. A. S., *strength of cast-iron tubbing for deep shafts*, 134.
Representatives on council of The Institution of Mining Engineers, election, 7.
Rescue-apparatus, demonstration, Felling, 178.
Ritter, Étienne A., coal- and lignite-fields of Rocky mountains, abs. 13.
Rocky mountains, coal-fields, abs. 13.
— —, lignite-fields, abs. 13.
Römerite, sulphate-of-iron mineral, abs. 16.
Ross, Arthur, circulation and heat absorption in steam boilers, 259.—Discussion, 269.
Ross, J. A. G., *circulation and heat absorption in steam boilers*, 269.
Rowley, Walter, mining and engineering in America and Canada, 111.—Discussion, 124, 157.
Rudler, F. W., *occurrence and commercial uses of fluorspar*, 231.
Russia, Grozny, oil-field, geology, abs. 89.
—, Neviansk, mining district, abs. 93.
Russian Central Asia, mineral industry, abs. 24.
Ruxton, W. L., *demonstration of rescue-apparatus, Felling, August 31st, 1907*, 187.

S.

Safety-lamp, Wolf-Bohres electric, 59.
St. John's island, Red Sea, precious chrysolite, abs. 15.
Sainte-Claire-Deville, —, simple method of water-stowage at No. 5 pit of Escarpelle mines, 159.—Discussion, 165.
Salt-mine, Desdemona, Germany, Hanover, explosion, abs. 35.
Sands, auriferous, gold in, determination, abs. 20.
Scharizer, R., sulphate-of-iron minerals: coquimbite, copiapite and römerite, abs. 16.
Schmeisser, —, mining developments in German colonies, abs. 2.
Secretaries, portraits, 241.
Servia, Bor, cupriferous deposits, abs. 94.
Sicily, sulphur, native, working of, abs. 26.
Silver-mines, Mexico, Arzate, abs. 28.
Simonds, J. J., *demonstration of rescue-apparatus, Felling, August 31st, 1907*, 192, 195.
Simonis, Henry, *demonstration of rescue-apparatus, Felling, August 31st, 1907*, 186.
Simpson, J. B., *presidential address*, 38.
Sinking of Bentley colliery, 168.
— purposes, locking hook for, 56, 151.
Smith, G. F. Herbert, yttrocrasite and paratacamite: two new minerals, abs. 20.
Stahl, A. F., origin of petroleum, etc., abs. 55.
Stanniferous deposits, Africa, Rhodesia, abs. 1.
— —, —, Transvaal, abs. 1.
Steam boilers, circulation and heat absorption in, 259.
Steavenson, A. L., *circulation and heat absorption in steam boilers*, 269.
—, death of M. Walton Brown, 104.
—, *deficiency in nomenclature of mineral deposits*, 110.
—, *mining and engineering in America and Canada*, 124.
—, portraits of past-presidents and secretaries, 242.
—, *report on circumstances attending explosion of fire-damp and coal-dust at Urpeth colliery*, 39.
Steel-works, Cargo Fleet, 237.
Steinhoff, —, choke-damp disaster in an Upper Silesian colliery, abs. 44.
Stowage, water-, Escarpelle mines, No. 5 pit, simple method, 159.
Stremme, H., formation of kaolin, abs. 57.
Strength of cast-iron tubbing for deep shafts, 80, 133, 167.
Stuart, Donald M. D., *report on circumstances attending explosion of fire-damp and coal-dust at Urpeth colliery*, 43.
Students, election, 14, 70, 107, 127, 166, 244.
—, list, app. ii., lvi.
Stutzer, O., tourmaline-bearing cobalt-deposits in Chile, abs. 12.
Subscribers, list, app. ii., lviii.
Suess, Franz E., Rossitz coal-field, Moravia, Austria, abs. 69.
Sulphate-of-iron minerals, abs. 16.
Sulphur, native, Sicily, working of, abs. 26.
—, United States of America, working of, abs. 26.
Sweden, northern, iron-ore deposits, abs. 94.

T.

Temperatures, underground, values of geothermic degree, abs. 48.
Tetrahedrite, frigidite a variety of, abs. 17.
Thiess, F., mineral industry in Russian Central Asia, abs. 24.
Tornow, M., use of excavators at brown-coal mines of Prussian Saxony, abs. 31.
Tourmaline-bearing cobalt-deposits, Chile, abs. 12.
Trüstedt, Otto, Pitkäranta ore-deposits, Finland, abs. 91.
Tubbing, cast-iron, strength, deep shafts, 80, 133, 167.
—, — —: what is its rational formula, 127, 167, 248.
Tyne Main colliery, electric pump, 66.

U.

Underground temperatures, values of geothermic degree, abs. 48.
United States of America, engineering, 111, 157.
—, Louisiana, sulphur, native, working of, abs. 26.
United States of America, mining, 111, 157.
—, Rocky mountains, coal-fields, abs. 13.
—, — —, lignite-fields, abs. 13.
Uranium-ores, German East Africa, abs. 5.

V.

Veins, fissure-, occurrence of kimberlite in, abs. 18.
Venator, Wilhelm, manganese-ores, abs. 21.
Villarello, Juan D., gold and silver-mines of Arzate, Mexico, abs. 28.
—, metalliferous mines of Zacualpan, Mexico, abs. 29.
Voit, F. W., occurrence of kimberlite in fissure-veins, etc., abs. 18.

W.

Walker, S. F., awarded G. C. Greenwell medal, 13.
Warren, C. H., and W. E. Hidden, yttrocrasite and paratacamite: two new minerals, abs. 20.
Water-stowage, Escarpelle mines, No. 5 pit, simple method, 159.
Watson, S., *occurrence and commercial uses of fluorspar*, 232.
Weeks, J. G., *mining and engineering in America and Canada*, 124.
—, portrait of M. Walton Brown, 105.
—, portraits of past-presidents and secretaries, 243.
—, *report on circumstances attending explosion of fire-damp and coal-dust at Urpath colliery*, 40.
Weeks, J. G., *Wolf-Bohres electric safety-lamp*, 60.
Weg rescue-apparatus, 181, 184.
Weinschenk, E., identification of copiapite with jánosite, abs. 16.
Westphalia rescue-apparatus, 182, 184.
Wienecke, O., arsenical ore-deposits of Reichenstein, Silesia, abs. 87.
Wigand, —, explosion at Desdemona salt-mine, Hanover, abs. 35.
Wolf-Bohres electric safety-lamp, 59.
Wood, E. Seymour, *demonstration of rescue-apparatus, Felling, August 31st, 1907*, 191, 194.
Wood, W. O., *deficiency in nomenclature of mineral deposits*, 109.
—, portrait of M. Walton Brown, 105.

Y.

Yttrocrasite, a new mineral, abs. 20.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

TRANSACTIONS.

VOL. LIX.

1908-1909.

EDITED BY THE SECRETARY.

NEWCASTLE-UPON-TYNE: PUBLISHED BY THE INSTITUTE

PRINTED BY ANDREW REID & CO., LIMITED, NEWCASTLE-UPON-TYNE.
1912.

[*All rights of publication or translation are reserved.*]

ADVERTIZEMENT.

The Institute is not, as a body, responsible for the statements and opinions advanced in the papers which may be read, nor in the discussions which may take place at the meetings of the Institute.

CONTENTS OF VOL. LIX.

PAGE.

ADVERTIZEMENT ii
CONTENTS iii

GENERAL MEETINGS.

1908. PAGE.

Aug. 1.—Annual General Meeting (Newcastle-upon-Tyne)... 1
Election of Officers, 1908-1909 1
Annual Report of the Council, 1907-1908 3
Annual Report of the Finance Committee 7
Accounts 9
G. C. Greenwell Medals 14
Representatives on the Council of The Institution of Mining Engineers, 1908-1909 14
Report of Delegate to the Jubilee Meeting of the Société de l'Industrie Minérale, 1908... 15
Oct. 10.—General Meeting (Newcastle-upon-Tyne) 22
Discussion of Mr. Arthur Ross's paper on "Circulation and Heat Absorption in Steam Boilers" 23
"Repairing Leaky Seams." By Ugo Bagnoli 31
Discussion 33
"The 'Bold' Box-controller and Box-switch." By J. G. Thompson 35
"Note on the Effect of an Igneous Dyke on a Natal Coal-seam." By G. H. Stanley 38
Discussion 39
"Note on a Deposit of Sulphur in a Colliery Water." By G. H. Stanley 41
Discussion 42
Safety-lamp for Detecting Small Quantities of Inflammable Gas 44
Dec. 12.—General Meeting (Newcastle-upon-Tyne) 45
Safety-lamp for Detecting Small Quantities of Inflammable Gas 46
Discussion on the Underground Fire at Hamstead Colliery ... 47
Discussion on the Explosion at Washington "Glebe" Colliery ... 54
"The Working of the Inclined Seams in the St. Étienne Coal-field, at the Montrambert and La Béraudière Collieries." By Hugh Clarkson Annett... 61
Old Wooden Pumps found in Rainton Colliery ... 92

1909.

Feb. 13.—General Meeting (Newcastle-upon-Tyne) 93
Discussion of Mr. Ugo Bagnoli's paper on "Repairing Leaky Seams" 94
"Memoir of Henry Lawrence." By John H. Merivale 96

1909.
Feb. 13.—General Meeting (Newcastle-upon-Tyne).—*Continued.* PAGE.
"Coal-mining on the Kirghese Steppe, in the Akmolinsk District of South-western Siberia." By Edward Watson 99
Discussion 107
April 3.—General Meeting (Newcastle-upon-Tyne) 109
Discussion of Mr. Hugh Clarkson Annett's paper on "The Working of the Inclined Seams in the St. Étienne Coal-field, at the Montrambert and La Béraudière Collieries" ... 110
"Hydraulic Stowing of Gob at Shamrock I. and II. Colliery, Herne, Westphalia, Germany." By Hugh Clarkson Annett 111
Discussion 129
"Notes on a Small Contrivance to more easily Detect Fire-damp." By W. C. Blackett 130
Discussion 131
Reading, Writing, and Smoke Rooms 134
1902.
Sept. 17.—Thirteenth Annual General Meeting of The Institution of Mining Engineers (Newcastle-upon-Tyne) 135
"Coal-shipment and the Laying-out of Staithe Heads, with Special Reference to Anti-breakage Appliances." By John Kirsopp, Jun. 136
1909.
June 12.—General Meeting (Newcastle-upon-Tyne) 253
"A Short Description of the Various Types of Coal Cargo-steamers and of Doxford's New Self-discharging Steamer." By John Kirsopp, Jun. 254
Discussion 275
Discussion of Mr. W. C. Blackett's "Notes on a Small Contrivance to more easily Detect Fire-damp" 279

APPENDICES.

1. Notes of Papers on the Working of Mines, Metallurgy, etc., from the Transactions of Colonial and Foreign Societies and Colonial and Foreign Publications... 1-104
"The Coal-basin of Guardo, Spain." By R. S. Lozano 1
"The Cupriferous Deposits of Northern Palencia, Spain." By R. A. de Yarza 2
"Manganese-ores of Ciudad Real, Spain." By R. Michael ... 3
"Metalliferous Deposits of Cartagena, Spain." By R. Pilz ... 4
"Mineral-deposits in the Early and Middle Tertiary Rocks of Spain." By L. Mallada 6
"Mineral-resources of Spain and Portugal." By Joh. Ahlburg 8
"Plumbiferous Deposits of the Sierra Nevada, Spain." By R. S. Lozano 13
"Stanniferous Deposits of Pontevedra Province, Spain." By R. S. Lozano 14
"Coal-mines, etc., of Southern Yunnan, China." By H. Lantenois, — Counillon, H. Mansuy, R. Zeiller, and L. Laurent 15

APPENDICES. —*Continued.*

I. —Notes of Papers, etc.—*Continued.* PAGE.

"Jadeite-deposits of Upper Burma." By A. W. G. Bleeck ... 17
"Ruby-deposits of Nanya-Zeik, Burma." By J. J. Tanatar ... 19
"Glauber's Salt-deposits and Brine-springs in the Yenisei Basin, Siberia." By M. A. Nowomejsky 20
"Recent Surveys in the Gold-bearing Regions of Siberia":—
(1) By A. Khlaponin 21
(2) By A. Khlaponin, P. Rippas, E. Ahnert, and M. Ivanov 21
(3) By A. Gerasimov 22
"Coal-measures in Southern Oran, Algeria." By H. Douvillé and R. Zeiller 22
"Phosphatic Deposits of Algeria and Tunisia." By O. Tietze 23
"A New Silicate of Copper from the French Congo." By A. Lacroix 24
"The Cupriferous Region of Kwilu-Niari, French Congo." By D. Levat 25
"Tsumeb Ore-deposits, German South-west Africa." By W. Maucher 28
"Petroleum in Angola, Portuguese West Africa." By João Carlos da Costa 29
"Salagasta Coal, Argentine Republic." By E. Herrero Ducloux 30
"Zinc-blende Deposit in Ouro Preto, Brazil." By Joaquim Candido da Costa Sena 31
"The Search for Coal in Southern Brazil." By B. J. dos Santos 31
"Coal-outcrops in the Paraná Region, Brazil." By E. P. de Oliveira 33
"Cobquecura Brown-coal Deposit, Chile." By Julio Schneider 34
"The Lignite- or Brown-coal Deposits of Chile, South America." By Miguel R. Machado 34
"The Bella Union Quicksilver-mines, Mexico." By Juan D. Villarello 36
"Cobalt in the State of Jalisco, Mexico." By D. V. Navarro... 38
"Borax-deposits of Salinas, Peru." By Alberto Jochamowitz... 39
"Mineral Resources of the Department of Cuzco, Peru." By Enrique J. Dueñas 40
"Mineral-district of Huancavelica, Peru." By Carlos E. Velarde 42
"Mineral Resources of the Province of Huamachuco, Peru." By Fermín Málaga Santolalla 44
"Mineral Resources of the Province of Santiago de Chuco, Peru." By Fermín Málaga Santolalla... 47
"Colorado Coals, United States of North America" —
(1) By W. P. Headden 49
(2) By W. P. Headden 49
"The Zinc-ores of La Mallieue (Belgium)." By H. de Rauw 51
"Iron-ores of the Forest of Lorges (Britanny)." By F. Kerforne 52
"Cupriferous and Nickeliferous Deposits in the Franconian Forest, Germany." By Albert Schmidt 53
"The Eisenzeche Iron-ore Belt, Germany." By — Resow 54

APPENDICES. —*Continued.*

I. Notes of Papers, etc. —*Continued.*

PAGE.

"Specular Iron-ore of the Fichtelgebirge, Germany." By Albert Schmidt ... 55
"The Almásszelistye Ore-deposits, Hungary." By Karl von Papp ... 56
"The Dobschau Ore-deposits (Upper Hungary)." By K. A. Redlich ... 58
"Lignite-deposits of Val di Bruna, Italy." By V. Novarese ... 58
"Discovery of Coal in Madagascar." By Marcellin Boule ... 60
"The Dombrowa Coal-field, Russian Poland." By S. J. Czarnocki ... 60
"Manganiferous Iron-ore Deposits of Brosteni, Rumania." By V. C. Butureanu ... 61
"Zigaza and Komarovo Iron-ore Deposits, Southern Urals." By L. Koniushevsky ... 62
"Iron-ores in the Swiss Jura." By E. Baumberger ... 63
"Gypsum-deposits in the Metalliferous Districts of Tuscany." By B. Lotti ... 64
"Bauxite-deposits in Eastern Hungary." By Richard Lachmann 66
"Auriferous Deposits of the Yenisei Region, Siberia." By A. K. Meister ... 67
"Jurassic Coal-seams of the Bureia Basin, Siberia." By A. Khlaponin ... 68
"Mineral Resources of Anatolia, Kurdistan, and Arabistan." By Bruno Simmersbach ... 69
"The South African Diamantiferous Deposits." By F. W. Voit 70
"Petroleum in the Orange River Colony." By G. J. Kellner ... 72
"The Petroliferous Belt of Northern Peru." By V. F. Masters 72
"Stanniferous Deposits of Bolivia and Prospecting for Tin in Peru." By E. A. L. de Romaño ... 74
"The Sulphur-deposits of Mapimí, Mexico." By Juan D. Villarello ... 76
"Tin-ore Deposits of the Herberton District, Queensland." By W. Edlinger ... 78
"The Fossil Plants of the Dombrowa Coal-field, Russia." By M. D. Zaliessky ... 80
"Georgiadesite, a new Plumbarseniferous Mineral." By A. Lacroix and A. de Schulten ... 81
"Jánosite identified with Copiapite." By Zoltán von Toborffy 82
"Gold-mining in the Fichtelgebirge, Germany." By Albert Schmidt ... 83
"Phosphate-mining in Belgium." By — Tietze 83
"Mineral Resources of Apurimac, Peru." By A. Jochamowitz 86
"König and Gützlaff Coal-wedging Machine." Anon. ... 88
"Safety-fuzes in France." Official ... 89
"Surface and Underground Subsidence in Coal-mining." By R. Hausse ... 91
"Unwatering of Strata and Subsidences in the Rhenish-Westphalian Coal-field." By R. Bärtling ... 91
"Electric Safety-lamp Experiments at Camphausen, Germany." By — Rossenbeck ... 93

APPENDICES.—*Continued.*

I. Notes of Papers, etc. · *Continued.* PAGE

"A New French Glass for Safety-lamps." By G. Chesneau ... 95
"The Müller Safety-lamp." By G. Chesneau 95
"Dust-explosion at the Gardanne Mine, France." By Rigaudias 96
"Colliery-explosions in Prussia during 1907." Official 98
"Underground Fires in Mines." By A. Aron 100
"The Salt-mining Industry in the Russian Empire." By F. Thiess 102
"Accidents at Electric Installations at Prussian Mines during 1907." Official 103

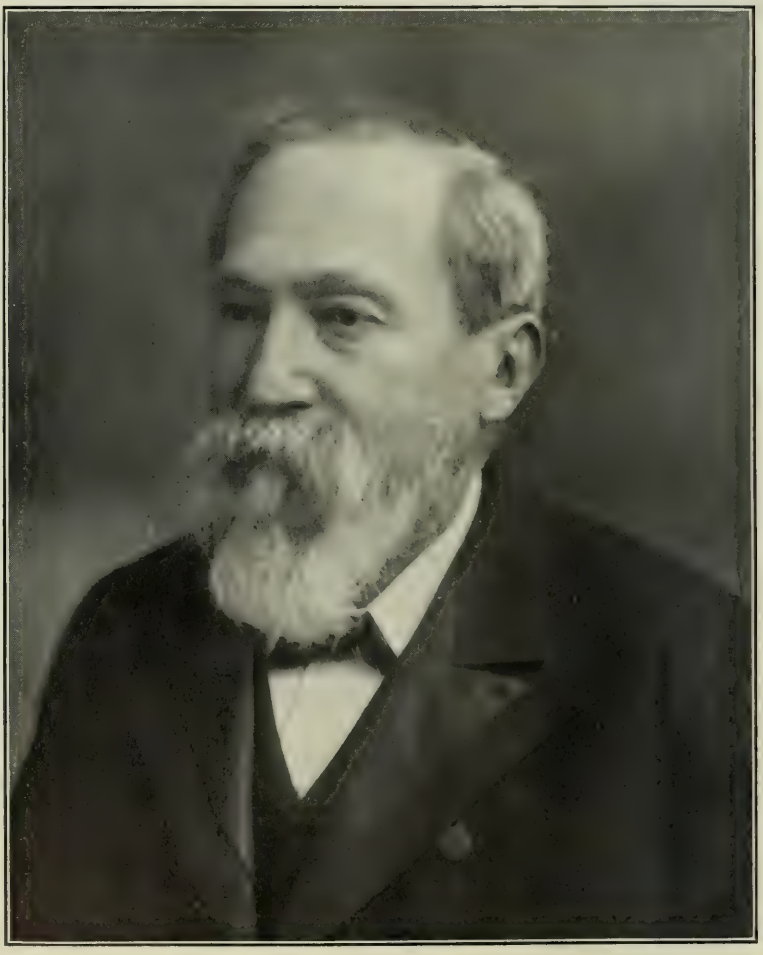
II.—List of Fatal and Non-fatal Explosions of Fire-damp or Coal-dust, and Barometer, Thermometer, etc., Readings for the Years 1907 and 1908. Compiled by Percy Strzelecki 105-124

III.—Annual Report of the Council and Accounts for the Year 1908-1909; List of Council, Officers and Members for the Year 1909-1910; etc. ... ... i-lix

INDEX 1-9

LIST OF PLATES:—

	PAGE.		PAGE.
PORTRAIT OF MR. HENRY LAWRENCE	*Frontispiece*	IV.	128
I.	36	V.	130
II., III.	92	VI., VII., VIII.	252
		IX.	280



HENRY LAWRENCE.

Born on October 7th, 1825, *and died on November 22nd*, 1908.

Presented by The North of England Institute of Mining and Mechanical Engineers.

THE NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
AUGUST 1ST, 1908.

MR. JOHN H. MERIVALE, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on July 18th and that day, and of the Council of The Institution of Mining Engineers.

ELECTION OF OFFICERS, 1908-1909.

The CHAIRMAN (Mr. John H. Merivale) appointed Messrs. Sidney Bates, C. A. Crofton, C. H. Merivale, N. B. Ridley, John Southern, and W. B. Wilson, jun., as scrutineers of the balloting-papers for the election of officers for the year 1908-1909.

The SCRUTINEERS afterwards reported the result of the ballot, as follows:—

PRESIDENT:
Mr. T. E. FORSTER.

VICE-PRESIDENTS:

Mr. J. B. ATKINSON.	Mr. W. C. BLACKETT.	Mr. M. W. PARRINGTON.
Mr. R. DONALD BAIN.	Mr. T. Y. GREENER.	Mr. JOHN SIMPSON.

COUNCILLORS:

Mr. R. S. ANDERSON.	Mr. T. E. JOBLING.	Prof. HENRY LOUIS.
Mr. SIDNEY BATES.	Mr. AUSTIN KIRKUP.	Mr. JOHN MORISON.
Mr. R. W. BERKLEY.	Mr. J. P. KIRKUP.	Mr. W. C. MOUNTAIN.
Mr. BENJAMIN DODD.	Mr. PHILIP KIRKUP.	Mr. A. D. NICHOLSON.
Mr. J. H. B. FORSTER.	Mr. HENRY LAWRENCE.	Mr. J. H. NICHOLSON.
Mr. A. M. HEDLEY.	Mr. C. C. LEACH.	Mr. R. L. WEEKS.

The Chairman (Mr. John H. Merivale) moved a vote of thanks to the Scrutineers for their services.

Mr. W. B. Wilson seconded the resolution, which was cordially adopted.

Mr. J. G. Weeks, in moving a vote of thanks to the President, Vice-Presidents, Councillors, and Officers, for their services during the past year, said that the President had had a good deal of extra work thrown upon him through the death of Mr. M. Walton Brown, since whose decease he had undertaken the duty of attending to the affairs of the Institute. The work in connexion with the suggested removal of the offices of The Institution of Mining Engineers from Newcastle-upon-Tyne to London had also absorbed a large share of his attention.

Mr. A. L. Steavenson seconded the motion, which was heartily adopted.

Mr. John H. Merivale, responding, said that the work during the past year had been more arduous than usual. He was most proud of the gallery of portraits of Past-Presidents and Secretaries, which was practically complete, the only portrait that it had been found impossible to obtain being that of Mr. Edward Sinclair, who acted as Honorary Secretary during the initial stages of the Institute's career.

Dr. P. Phillips Bedson moved a vote of thanks to the representatives of the Institute on the Council of The Institution of Mining Engineers for their services during the past year.

Mr. A. D. Nicholson, H.M. Inspector of Mines, seconded the proposal, which was cordially adopted.

The Annual Report of the Council was read as follows:—

ANNUAL REPORT OF THE COUNCIL, 1907-1908.

The Council regret to have to place on record the great loss that the Institute has sustained by the death of the Secretary, Mr. M. Walton Brown. Mr. Brown's connexion with the Institute dated back to the year 1871, when he was elected a student, his transference to the class of member taking place in the year 1878. He was elected a Member of Council in the year 1887, serving continuously thereon until the year 1891, when he was appointed the Secretary of the Institute. His connexion with the Institute was such a lengthy one, he had so complete a knowledge of its affairs in every detail, and he was always so ready to place his services and stores of information upon all subjects relating to mining at the disposal of the members, that his loss to the Institute is well nigh irreparable. An interesting memoir has been written by Mr. H. F. Bulman, and published in the *Transactions*.

The Council, after a careful consideration of the question of appointing a successor to Mr. Brown, decided that it would be to the interests of the Institute "That the Secretaryship be vested in an Honorary Secretary, for a period not exceeding two years, and that Mr. T. E. Forster be asked to accept the position." Mr. Forster expressed his willingness to act, but has now vacated the position, he having been nominated for the office of President for the ensuing year. Mr. John H. Merivale has accepted the Honorary Secretaryship, and the Institute will retain the services of Mr. Lawrence Austin as Secretary, Mr. Austin having assisted the late Mr. Brown and his predecessor for a period of twenty years. It is confidently hoped that these arrangements will conduce to the prosperity of the Institute.

The following table shows the progress of the membership during recent years :—

Year ending August 1st.	1902.	1905.	1908.
Honorary members	25	24	21
Members	893	953	942
Associate members	109	113	105
Associates	122	178	209
Students	66	56	48
Subscribers	23	28	33
Totals	1,238	1,352	1,358

The Library has been maintained in an efficient condition during the year; the additions, by donation, exchange, and purchase, include 250 bound volumes and 17 pamphlets, reports, etc.; and the Library now contains about 11,550 volumes and 380 unbound pamphlets. A card-catalogue of the books, etc., contained in the Library renders them easily available for reference.

Members would render useful service to the profession by the presentation of books, reports, plans, etc., to the Institute, to be preserved in the Library, and thereby become available for reference.

The courses of lectures for colliery engineers, enginewrights, and apprentice mechanics, have been continued at Armstrong College, Newcastle-upon-Tyne. The lectures are delivered on Saturday afternoons, and the three years' course embraces the following subjects:—

1908-1909. Michaelmas Term, (1) Transmission of Power, and (2) Pumping and Ventilation. Epiphany Term, (3) Metallurgy of Iron and Steel, and (4) Mining Machinery (mainly machinery used underground).

1909-1910. Michaelmas Term, (5) Machine Drawing, and (6) the Chemistry of Fuel. Epiphany Term, (7) Strength of Materials (with experimental illustrations), and (8) Experimental Mechanics.

1910-1911. Michaelmas Term, (9) The Steam-engine, and (10) Theoretical Electricity. Epiphany Term, (11) Electrical Engineering, and (12) Haulage and Winding.

Several colliery-owners have paid the fees (£1 10s. per annum) and railway expenses of pupils attending the classes from their collieries. During the past year, the lectures of the Michaelmas Term on the Steam-engine were attended by 27 students, and Theoretical Electricity by 23 students, 27 of whom sat for examination and 17 passed; and, during the Epiphany Term, the lectures on Electrical Engineering were attended by 23 students, and upon Haulage and Winding by 24 students; 22 of these were examined and 15 passed. The first prize for the Session 1907-1908 has been awarded to Mr. P. Bateson, who gained the highest aggregate number of marks; Messrs. A. Elliott and H. E. English dividing the second prize.

Supplementary volumes to *An Account of the Strata of Northumberland and Durham, as proved by Borings and Sinkings*, are in course of publication, a large number of sections having been received from members and other friends.

The Council have decided not to continue the compilation and

publication of the "Subject-matter Index of Mining, Mechanical, and Metallurgical Literature."

Mr. Thomas Douglas continues to represent the Institute as a Governor of Armstrong College, and Mr. John H. Merivale, in conjunction with the President (Mr. T. E. Forster), represents the Institute on the Council of the College.

Mr. George May continues to represent the Institute upon the Board of Directors of the Institute and Coal Trade Chambers Company, Limited.

Mr. James Heppell Marr will represent the Institute at the Conference of the Corresponding Societies of the British Association for the Advancement of Science, to be held in Dublin, commencing on September 2nd, 1908. The Société de l'Industrie Minérale celebrated the Fiftieth Anniversary of its Foundation in June, 1908, and Mr. Arthur Morton Hedley represented the Institute thereat, and presented an Address.

A G. C. Greenwell gold medal has been awarded to Dr. P. Phillips Bedson for his "Experiments illustrative of the Inflammability of Mixtures of Coal-dust and Air."

Prizes for books have been awarded to the writers of the following papers, communicated to the members during the year 1906-1907: -

* "Experiments illustrative of the Inflammability of Mixtures of Coal-dust and Air." By Dr. P. Phillips Bedson, D.Sc., Hon. M.I.M.E., and Mr. Henry Widdas, M.I.M.E.

"Treatment of Dust in Mines, Aboveground and Belowground." By Mr. Richard Harle, M.I.M.E.

"The Valuation of Mineral Properties." By Mr. Thomas Aloysius O'Donahue, M.I.M.E.

"Sinking through Magnesian Limestone and Yellow Sand by the Freezing-process at Dawdon Colliery, near Seaham Harbour, County Durham." By Mr. Ernest Seymour Wood, M.I.M.E.

Under the will of the late Mr. John Daglish, funds have been placed at the disposal of Armstrong College for founding a Travelling Fellowship, to be called the "Daglish" Fellowship, candidates for which must be nominated by the Institute. Mr. Hugh Clarkson Annett was in January, 1908, awarded the Fellowship, and suitable arrangements for his gaining knowledge and experience in France were made, and similar arrangements will be made for a visit to Germany.

* The prize for books is awarded to Mr. Widdas, Dr. Bedson having been awarded a G. C. Greenwell gold medal.

Excursion meetings were held at Dunston-upon-Tyne on August 29th, 1907, when the members inspected the ferro-concrete constructions of the Co-operative Wholesale Society, Limited; at Felling on August 31st, 1907, when the members were present at the annual inspection of the Felling Colliery Corps (No. 6 District) of the St. John Ambulance Brigade, and also witnessed a demonstration of rescue-apparatus, and inspected the electric pumping-plant at Tyne Main colliery; and at South Bank on October 30th, 1907, when the members inspected the Cargo Fleet Steel- and Iron-works of the Cargo Fleet Iron Company, Limited.

In connexion with the demonstration of rescue-apparatus at Felling, an interesting exhibition of the various types of apparatus used was held in the Wood Memorial Hall.

The thanks of the Institute have been sent to the owners of the collieries, works, etc., visited during the year.

The papers printed in the *Transactions* during the year are as follows:—

"Demonstration of Rescue-apparatus, Felling, August 31st, 1907." By Mr. Lawrence Austin.

"Experiments illustrative of the Inflammability of Mixtures of Coal-dust and Air." Part II. By Dr. P. Phillips Bedson, D.Sc., Hon. M.I.M.E., and Mr. Henry Widdas, M.I.M.E.

"Memoir of Martin Walton Brown." By Mr. Harrison Francis Bulman, M.I.M.E.

"Wolf-Bohres Electric Safety-lamp." By Mr. Richard Cremer.

"The Occurrence and Commercial Uses of Fluorspar." By Mr. William Morley Egglestone.

"Flinty Chert, Hornstone, etc." By Mr. Thomas Harker.

"A Locking Hook for Sinking Purposes." By Prof. Henry Louis, M.I.M.E.

"On a Deficiency in the Nomenclature of Mineral Deposits." By Prof. Henry Louis, M.I.M.E.

"Presidential Address." By Mr. John Herman Merivale, M.I.M.E.

"The Strength of Cast-iron Tubbing for Deep Shafts." By Dr. John Morrow.

"Circulation and Heat Absorption in Steam Boilers." By Mr. Arthur Ross.

"Notes on Mining and Engineering in America and Canada." By Mr. Walter Rowley, M.I.M.E.

"A Simple Method of Water-stowage employed at No. 5 Pit of the Escarpelle Mines." By Mr. Sainte-Claire-Deville.

"Ferro-concrete Work at Dunston-upon-Tyne."

"Electric Pump at Tyne Main Colliery."

"Cargo Fleet Steel- and Iron-works."

The Institution of Mining Engineers has now entered upon its twentieth year, and the members are to be congratulated upon its continued success and the increasing membership of the

associated institutions. Meetings of the members were held in Sheffield in September, 1907, and in London in June, 1908, the attendance in each case being satisfactory.

Since the death of Mr. Martin Walton Brown, who was also Secretary of The Institution of Mining Engineers, Mr. Percy Strzelecki has acted as Secretary *pro tem.*, he having been an official of the Institution for the past seventeen years.

During the past year Mr. Thomas Douglas and the President (Mr. John Herman Merivale) have represented the Institute upon the Status and Qualifications of Membership Committee, and Mr. John George Weeks and the President (Mr. John Herman Merivale) upon the Secretaryship, Headquarters, and Status and Qualifications of Membership Committee of The Institution of Mining Engineers. As a result of the deliberations of these Committees, it has been decided that the Secretaryship of The Institution of Mining Engineers shall, in future, not be held by the Secretary of any one of the Federated Institutes, and that the headquarters of the Institution shall be removed to London. This will naturally result in increased working costs, which will be met for the first three years by the several Federated Institutes contributing to a guarantee fund *pro rata* to their membership.

The Report of the Finance Committee was read as follows:—

ANNUAL REPORT OF THE FINANCE COMMITTEE.

The Finance Committee submit herewith a statement of accounts for the twelve months ending June 30th, 1908, duly audited.

The total receipts were £2,867 2s. Of this amount, £21 was paid as a life-composition in lieu of annual subscriptions, and £40 14s. as subscriptions paid in advance, leaving £2,805 8s. as the ordinary income of the year, compared with £2,928 1s. 3d. in the previous year. The amount received for ordinary current-year subscriptions was £2,218 10s., and arrears £239 18s., as against £2,264 17s. and £318 9s. respectively in the year 1906-1907. *Transactions* sold realized £11 5s. 8d., as compared with £19 3s. 9d. in the earlier period; the sum received for interest on investments was £335 14s. 4d., the amount in the former year being £325 11s. 6d.

The expenditure was £2,627 2s. 3d., that for the previous

year being £2,622 13s. 3d. Referring to the items making up the total, the sum of £521 17s. 3d. was paid within the year for salaries and wages, as compared with £531 6s. 6d. during the previous year; this reduction is in consequence of the interval during which there has been no paid Secretary, and would have been larger but for the engagement of temporary assistance in the compilation of the Library Catalogue and the "Subject-matter Index of Mining, Mechanical, and Metallurgical Literature." In the year 1906-1907 special expenditure was incurred in connexion with the visit of the American Institute of Mining Engineers and the experiments on coal-dust conducted at Armstrong College. The only special expenditure this year is for the cost of printing the volume of the "Subject-matter Index of Mining, Mechanical, and Metallurgical Literature" for the year 1902. Increased expenditure is shown for printing circulars and advance copies of papers, furniture and repairs, heating and lighting, postages, and in the payments to The Institution of Mining Engineers.

The figures cited above show that the income exceeded the expenditure by £239 19s. 9d., and adding to this the balance of £752 9s. brought forward from the previous year, a total balance of £992 8s. 9d. remains to the credit of the Institute. Of this amount, £487 13s. 6d. has been invested in the purchase of stock of the Newcastle and Gateshead Gas Company, leaving the sum of £504 15s. 3d. to carry forward.

The names of 28 persons have been struck off the membership list in consequence of non-payment of subscriptions. The amount of subscriptions written off was £227 5s., of which £74 14s. was for sums due for the year 1907-1908, and £152 11s. for arrears. It is probable that a considerable proportion of these amounts will be recovered and credited in future years. Of the amounts previously written off, £59 19s. was recovered during the past year.

JOHN H. MERIVALE, *President.*

August 1st, 1908.

The CHAIRMAN (Mr. John H. Merivale), in moving the adoption of the Annual Reports of the Council and Finance Committee, remarked that they were both of a very satisfactory nature.

Mr. A. L. STEAVENSON seconded the resolution, which was adopted.

The North of England Institute of Mining and Mechanical Engineers: General Statement, June 30th, 1908.

Liabilities.

	£	s.	d.	£	s.	d.
Subscriptions paid in advance during the current year				40	14	0
The Institution of Mining Engineers				18	1	7
The George Clementson Greenwell prize fund	100	0	0			
Less, paid for medals	70	1	4			
				29	18	8
Printing, etc.				12	0	6
Capital				12,643	9	3
				£12,744	4	0

We, having examined the above account with the books, vouchers and securities relating thereto, certify that, in our opinion, it is correct. We have accepted the assets, books, pictures, maps, etc., and *Transactions* and other publications, as valued by your officials.

JOHN G. BENSON AND SONS,
Chartered Accountants.

Newcastle-upon-Tyne,
July 30th, 1908.

Assets.

	£	s.	d.	£	s.	d.
Balance of account at bankers	424	16	4			
,, in Treasurer's hands	77	12	3			
Outstanding accounts due from authors for excerpts	2	6	8			
				504	15	3
Arrears of subscriptions				280	6	0
179 shares in the Institute and Coal-trade Chambers Company, Limited (at cost) ...	4,100	0	0			
Institute and Coal-trade Chambers Company, Limited (mortgage)	1,400	0	0			
£340 consolidated 5 per cent. preference stock of the Newcastle and Gateshead Water Company (at cost)	499	17	6			
£450 ordinary stock of the Newcastle and Gateshead Gas Company (at cost)	487	13	6			
				6,487	11	0
(Of the above amount, £1,659 is due to life-subscriptions account.)						
Value of *Transactions* and other publications, as per stock account	321	11	9			
Books, pictures, maps, furniture and fittings	5,150	0	0			
				5,471	11	9
				£12,744	4	0

DR. THE TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND FOR THE YEAR ENDING

	£ s. d.	£ s. d.
June 30th, 1907.		
To balance of account at bankers	711 4 7	
„ „ in Treasurer's hands	38 5 11	
„ outstanding accounts due from authors for excerpts	2 18 6	
		752 9 0
June 30th, 1908.		
To dividend of 7½ per cent. on 179 shares of £20 each in the Institute and Coal-trade Chambers Company, Limited, for the year ending June 30th, 1908 ...	268 10 0	
„ interest on mortgage of £1,400 with the Institute and Coal-trade Chambers Company, Limited	47 15 6	
„ dividend on £340 consolidated 5 per cent. preference stock of the Newcastle and Gateshead Water Company	16 3 0	
„ dividend on £450 ordinary stock of the Newcastle and Gateshead Gas Company	3 5 10	
		335 14 4
To sales of *Transactions*		11 5 8
To SUBSCRIPTIONS FOR 1907-1908 AS FOLLOWS:—		
726 members ... ... @ £2 2s.	1,524 12 0	
84 associate members ... ... @ £2 2s.	176 8 0	
160 associates ... ... @ £1 5s.	200 0 0	
41 students ... ... @ £1 5s.	51 5 0	
63 new members ... ... @ £2 2s.	132 6 0	
6 new associate members ... ... @ £2 2s.	12 12 0	
30 new associates ... ... @ £1 5s.	37 10 0	
18 new students ... ... @ £1 5s.	22 10 0	
	2,157 3 0	
32 subscribing firms	115 10 0	
	2,272 13 0	
1 member, paid a life-composition	21 0 0	
	2,293 13 0	
Less, subscriptions for current year paid in advance at end of last year	54 3 0	
	2,239 10 0	
Add, arrears received	239 18 0	
	2.479 8 0	
Add, subscriptions paid in advance during current year	40 14 0	
		2,520 2 0
		£3,619 11 0

INSTITUTE OF MINING AND MECHANICAL ENGINEERS Cr.
JUNE 30TH, 1908.

June 30th, 1908.	£	s.	d.	£	s.	d.
By *Annual Report*	41	6	0			
„ bankers' charges	21	11	4			
„ circulars and advance copies of papers	83	8	8			
„ cleaning Wood Memorial Hall, offices, etc.	35	5	2			
„ electric light	36	10	9			
„ expenses of meetings	2	18	1			
„ fuel	29	12	2			
„ furniture and repairs	51	13	3			
„ George Clementson Greenwell prize fund: medals ...	2	13	0			
„ incidental expenses...	2	12	1			
„ insurance	13	5	9			
„ investments	487	13	6			
„ lecture theatre	10	10	0			
„ library: binding £62 12 10						
„ .. books 12 8 8						
	75	1	6			
„ petty cash	2	1	1			
„ portraits of presidents	35	9	0			
„ postages: circulars £34 13 3½						
„ „ correspondence 16 13 9						
„ „ publications 41 10 8½						
	92	17	9			
„ prizes for papers	18	18	0			
„ rates and taxes	6	12	5			
„ rent of offices	24	8	0			
„ reporting of general meetings	12	12	0			
„ salaries, wages, auditing, etc.	521	17	3			
„ stationery, etc.	20	10	4			
„ *Subject-matter Index of Mining, Mechanical, and Metallurgical Literature*	68	13	6			
„ translations of papers	1	15	0			
„ travelling expenses	12	1	3			
„ water rate	2	18	8			
„ Wood Memorial Hall	10	10	0			
				1,725	5	6
By The Institution of Mining Engineers	1,394	2	11			
Less, amounts paid by authors for excerpts	4	12	8			
				1,389	10	3
				3,114	15	9
By balance of account at bankers	424	16	4			
„ „ in Treasurer's hands	77	12	3			
„ outstanding accounts due from authors for excerpts	2	6	8			
				504	15	3
				£3,619	11	0

DR. THE TREASURER OF THE NORTH OF ENGLAND INSTITUTE OF MINING

		£ s. d.	£ s. d.	£ s. d.
To 903 members,				
51 of whom have paid life-compositions.				
852				
5 not included in printed list.				
857	@ £2 2s.	1,799 14 0		
1 paid a life-composition		21 0 0		
			1,820 14 0	
To 108 associate members.				
9 of whom have paid life-compositions				
99	@ £2 2s.		207 18 0	
To 194 associates,				
1 of whom has paid a life-composition.				
193				
6 paid as members.				
187	@ £1 5s.		233 15 0	
To 47 students,				
1 paid as a member.				
46	@ £1 5s.		57 10 0	
To 34 subscribing firms			119 14 0	
				2,439 11 0
To 63 new members	@ £2 2s.		132 6 0	
To 6 new associate members	@ £2 2s.		12 12 0	
To 30 new associates	@ £1 5s.		37 10 0	
To 18 new students	@ £1 5s.		22 10 0	
				204 18 0
To arrears, as per balance sheet, 1906-1907			336 14 0	
Add, arrears considered irrecoverable, but since paid ...			59 19 0	
				396 13 0
				3,041 2 0
To subscriptions paid in advance				40 14 0
				£3,081 16 0

AND MECHANICAL ENGINEERS IN ACCOUNT WITH SUBSCRIPTIONS, 1907–1908. CR.

		PAID.	UNPAID.	STRUCK OFF LIST.
		£ s. d.	£ s. d.	£ s. d.
By 726	members, paid ... ... @ £2 2s.	1,524 12 0	.....	.....
104	,, unpaid ... @ £2 2s.	.....	218 8 0	.....
4	,, excused payment @ £2 2s.	.....	.....	8 8 0
3	,, dead ... ... @ £2 2s.	.....	.....	6 6 0
20	,, struck off list @ £2 2s.	.....	.....	42 0 0
857				
1	,, paid a life-composition	21 0 0	.....	.....
By 84	associate members, paid @ £2 2s.	176 8 0	.....	.....
11	,, ,, unpaid @ £2 2s.	.....	23 2 0	.....
4	,, ,, struck off list @ £2 2s.	.....	.....	8 8 0
99				
By 160	associates, paid ... ... @ £1 5s.	200 0 0	.....	.....
22	,, unpaid ... @ £1 5s.	.....	27 10 0	.....
1	,, excused payment @ £1 5s.	.....	.....	1 5 0
1	,, dead ... @ £1 5s.	.....	.....	1 5 0
3	,, struck off list @ £1 5s.	.....	.....	3 15 0
187				
By 41	students, paid ... ... @ £1 5s.	51 5 0	.....	.....
1	,, unpaid ... @ £1 5s.	.....	5 0 0	.....
1	,, struck off list @ £1 5s.	.....	.....	1 5 0
46				
By 32	subscribing firms, paid	115 10 0	.....	.....
1	,, ,, unpaid	.....	2 2 0	.....
1	,, ,, excused payment ...	.....	.....	2 2 0
34				
By 63	new members, paid ... @ £2 2s.	132 6 0	.....	.....
By 6	new associate members, paid @ £2 2s.	12 12 0	.....	.....
By 30	new associates, paid ... @ £1 5s.	37 10 0	.....	.....
By 18	new students, paid ... @ £1 5s.	22 10 0	.....	.....
		2,293 13 0	276 2 0	74 14 0
By arrears	... ...	239 18 0	4 4 0	152 11 0
		2,533 11 0		
By subscriptions paid in advance	... ...	40 14 0	.....	.....
		2,574 5 0	280 6 0	227 5 0
				280 6 0
				2,574 5 0
				£3,081 16 0

G. C. GREENWELL MEDALS.

The Chairman (Mr. John H. Merivale) presented the G. C. Greenwell gold medal, which had been awarded by the Council, to Dr. P. Phillips Bedson for his "Experiments Illustrative of the Inflammability of Mixtures of Coal-dust and Air."* Dr. Bedson, he said, had been connected with the Institute for about 25 years, and, during the whole of that time, he had placed his very great abilities and his excellent laboratory and appliances at their disposal. The first work that Dr. Bedson undertook for them was in connexion with the explosion of an air-receiver at Ryhope colliery, and he had stuck to the question of the explosion of coal-dust, communicating the results of his various experiments to the members. He (Mr. Merivale) hoped that Dr. Bedson would get to the bottom of the matter and succeed in mastering it entirely.

Dr. P. Phillips Bedson said that he felt truly grateful for the great distinction which the Council of the Institute had that day conferred upon him, and it was an especial pleasure that the presentation should be made by his old friend and colleague, Mr. Merivale.

REPRESENTATIVES ON THE COUNCIL OF THE INSTITUTION OF MINING ENGINEERS, 1908-1909.

The Chairman (Mr. John H. Merivale) moved, and Mr. A. L. Steavenson seconded, a resolution that the following gentlemen be elected as the representatives of the Institute on the Council of The Institution of Mining Engineers for the year 1908-1909:—

Mr. R. S. Anderson.
Mr. W. Armstrong.
Mr. R. C. Aubrey.
Mr. W. C. Blackett.
Mr. B. H. Brough.
Mr. A. G. Charleton.
Mr. Frank Coulson.
Mr. Benjamin Dodd.
Mr. T. E. Forster.
Mr. J. W. Fryar.
Mr. W. Galloway.
Mr. T. Y. Greener.
Mr. Reginald Guthrie.
Mr. Samuel Hare.
Mr. A. M. Hedley.
Mr. J. P. Kirkup.
Mr. Philip Kirkup.
Mr. C. C. Leach.
Mr. George May.
Mr. J. H. Merivale.
Mr. J. J. Prest.
Mr. John Simpson.
Mr. C. H. Steavenson.
Mr. J. G. Weeks.
Mr. R. L. Weeks.

The resolution was agreed to.

---

* *Trans. Inst. M. E.*, 1906, vol. xxxii., page 529.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. RICHARD PURDY, Colliery Manager, Katrasgarh P.O., E.I.R., Bengal, India.

Mr. HENRY MORTON SCHMIDT, Chief Engineer, United Coal Company, 804, Bank for Savings Building, Pittsburgh, Pennsylvania. U.S.A.

Mr. GEORGE WHYEL, Mining Engineer, First National Bank Building, Uniontown, Pennsylvania, U.S.A.

Mr. JOSEPH LEONARD WILLEY, Metallurgical Engineer, Société des Mines de Tuco Cheira, Puerto Supe, Peru, South America.

STUDENT—

Mr. WILLIAM RIDLEY, Mining Student, 10, Railway Street, Tow Law, S.O., County Durham.

REPORT OF DELEGATE TO THE JUBILEE MEETING OF THE SOCIÉTÉ DE L'INDUSTRIE MINÉRALE, 1908.

The report of Mr. A. M. HEDLEY, the delegate representing the Institute, was presented as follows:—

BLAYDON BURN,
BLAYDON-UPON-TYNE, S.O.,
COUNTY DURHAM,
July 15th, 1908.

To the President, Vice-Presidents, Councillors, and Members of The North of England Institute of Mining and Mechanical Engineers.

GENTLEMEN,

As your representative, I attended the recent Congress at St. Étienne, celebrating the Jubilee of the inauguration of the Société de l'Industrie Minérale. The meeting commenced on June 14th, about 430 members out of a total membership of 1,400 attending. Six of the other technical societies of France were represented, two delegates were present from Germany, and two from England, Mr. Bennett H. Brough, who represented the Iron and Steel Institute, and myself.

The Congress was opened on June 14th, with a meeting at the headquarters of the Society under the presidency of Mr. L. Tauzin, Chief Inspector of Mines and President of the Society: evening meetings being held upon the two following days, at both of which Mr. Tauzin again presided, when the following interesting papers were read:—

"The Working of Seams liable to Outbursts of Carbon Dioxide." By Mr. J. Bureau.

"The Jubilee of the Commentry-Fourchambault Company." By Mr. H. Fayol.

"Economic and Industrial Monopolies." By Mr. Francis Laur.

"Theories of the Formation of Coal." By Mr. L. Lemière.

"The Safety-lamp." By Mr. J. B. Marsaut.

"The Application of Turbo-machines to Mines and Metallurgical Works." By Mr. Auguste Rateau.

"Hydraulic Stowing in Mines." By Mr. P. H. de Renneville.
"The Mining Industry of the Loire Coal-field." By Mr. J. Siegler.
"The Metallurgical Industry of the Loire District." By Mr. A. Vicaire.

A banquet, at which nearly all taking part in the Congress were present, was held in the large hall at the headquarters of the Society, when the President (Mr. L. Tauzin) presented gold medals to those members of the Société de l'Industrie Minérale who had especially distinguished themselves during the past fifty years, the recipients being Messrs. L. Aguillon, H. le Chatelier, G. Chesneau, H. Fayol, A. François, J. B. Marsaut, A. Pourcel, Auguste Rateau, and E. Reumaux. I took the opportunity of publicly handing over your congratulatory Address to the President, when it was very cordially received, and I was desired to convey to you the thanks of the members of the Société de l'Industrie Minérale. Both the President and Mr. D. Murgue made reference to the friendly relationship existing between their Society and The North of England Institute of Mining and Mechanical Engineers. Mr. Bennett H. Brough, on behalf of the members of the Iron and Steel Institute, also presented an Address.

A conversazione, thoroughly appreciated and enjoyed by everyone, took place on June 18th.

Arrangements were made for members of the mining and metallurgical sections to visit various steel- and engineering-works and collieries in the neighbourhood of St. Étienne, the excursions extending over the four days, June 15th to 18th; and, on the two days following, to Rochetaillée, to Le Puy-en-Velay, and to Mont Pilat. Mr. Henri Verney, the Treasurer of the Society, who acted as organizing Secretary, was responsible for the admirable way in which all the excursions were conducted.

The members of the metallurgical section visited steel-works at Unieux, Firminy, St. Étienne, and St. Chamond; the engineering-works of Crozet-Fourneyron, of Traglaine, and of Palle-Bertrand, in St. Étienne; the works of Biétrix Le Flaive & Company at La Chaléassière; a large electric-power station at Montand; the French Government manufactory of arms and cycles in St. Étienne; the works of Marrel Brothers at Couzin; and engineering-works at l'Horme.

The members of the mining section visited the Dolomieu, Combes, Monterrad II., and Malafolie II. pits of the Compagnie des Mines de Roche-la-Molière et Firminy; the Montmartre and Loire pits of the Société Anonyme des Mines de la Loire; the Ferouillat, Dyèvre, St.-Dominique, St.-Joseph, Ondaine, Devillaine, Lyon, and Marseille pits of the Société Anonyme des Houillères de Montrambert et de la Béraudière; the Mars pit of the Société Anonyme des Houillères de St. Étienne; and the Gillier pit of the Compagnie des Mines de la Péronnière. A visit was also paid to the steel-works of the Marine (Aciéries de la Marine) at St. Chamond.

A few notes made on the collieries visited by the mining section may be of interest. Owing to the large number of places visited in the very limited time, they are necessarily short and incomplete, and are confined to observations upon points solely connected with the surface-arrangements and plant, for there was neither time nor opportunity for underground inspection. It would seem best, in the absence of complete detailed information, to mention merely special points of interest about the collieries generally, and they are simply presented as the outstanding features with which the writer, personally, was most impressed in his hurried and casual inspection.

Collieries.—The collieries visited were amongst the largest and most

up-to-date of those of the Loire coal-field, and it should be mentioned that some of the colliery companies are possessed of concessions or royalties granted by government, of very considerable area, notably those of the Compagnie des Mines de Roche-la-Molière et Firminy, which extend over some 14,400 acres. The coal-output from the nine pits of this concern in the year 1907 was 827,578 tons. It is noteworthy, as instancing the measures taken to provide a good saleable commodity, that nearly 40 per cent. of this was washed. In the same year 17,424 tons of briquettes were manufactured, and 26,443 tons of coke made.

Coal-seams.—The coal-seams found in the St. Étienne district are thirty-three in number; they are from 3 to 66 feet in thickness ("Grande Couche," 65½ feet or 20 metres); and those worked provide nearly every class of fuel for the market. Their inclination varies from 20 to 80 degrees from the horizontal; and, owing to their irregularity in this respect, the main winnings from the shafts are generally driven as levels across the strata, and a number of seams worked to the one set of levels.

Some of the seams are naturally very fiery, and, presumably having regard to this and to the extreme thickness of others, and to ensure protection for the surface, it is now compulsory by law to stow the goaf formed as the coal is worked out. To provide material for stowage, a large stone-quarry is worked in conjunction with nearly every colliery, the stone wrought being sent down the upcast shaft for stowing operations to be carried on at night-time. Beyond the heavy expense of this, combined with a high timbering cost, the transport of the material into the mine must necessarily interfere considerably with the essential coal-production. To a certain extent it accounts for the comparatively small outputs of collieries which, to judge by their large and costly equipments, should be capable of turning out much larger quantities of coal. In this respect it should not be inferred that money has been lavishly or wastefully spent in unnecessarily elaborate or ornamental erections. The prevailing idea seems to be, from the very commencement of a colliery, to instal machinery capable of coping with the full output to be expected after the mines have been fully developed; the machinery is of the most up-to-date description, showing evidence of the desire to work with every possible economy: and the whole of the plant is housed in buildings of substantial construction and of neat appearance.

Heapsteads and Winding-arrangements.—The general practice in the St. Étienne district is to have the shaft-top and screening establishment, and sometimes the winding-engine also, totally enclosed in one structure of brick- or masonry-work, with the steel headgear built into, or, in some cases, surmounting, the building.

The winding-engines at the older collieries are of the vertical type, with elaborate valve-gear. Two recent equipments, however, are exceptions: that at the St.-Dominique pit, built by Biétrix Le Flaive & Company, having a pair of horizontal cylinders 2 feet 7½ inches in diameter by 5 feet 3 inches stroke. The engine works with expansion, and is fitted with Collmann valves. A peculiar feature about it is that, on account of its insecure foundation, it has been built on a steel girder framework, which is readily capable of adjustment to true level in case of the ground's subsidence. Distinctly the finest engine seen was that at the Gillier pit (2,850 feet deep) at La Péronnière. It was built at the works of l'Horme, has a pair of horizontal cylinders 3 feet 11 inches in diameter by 6 feet 6½ inches stroke, and is fitted with Rider expansion-gear. Unlike any other plant seen, this engine has steel-wire ropes fitted to its drums (the others have aloe ropes) and a tail balance-

rope is suspended from the cages. There is also a very fine steel lattice-work headgear at this pit. In every winding-engine house there is an auxiliary engine or winch. Every facility is provided for ready inspection of all parts of the engines and for repairing operations, and, no doubt, this largely accounts for the fine condition in which the working parts are kept.

The winding-ropes are nearly all of aloe, the majority being tapered.

The cages vary in construction, but, on the whole, are similar to those at present in favour in England. The larger pits have cages with two and three decks; but, although arrangements for facilitating quick discharge or change of tubs are thus available, the actual time spent in changing is in many cases too long; and probably this may be partly attributable to the use of the flat aloe rope, with the unavoidable difference in diameter of the rope-rolls on the drums. Nearly all the shafts are fitted with steel-rail guides, with the Briart attachment to steel cross-girders, each cage being run on only two guides.

The banking-out arrangements are primitive, and it is the exception to see any mechanical arrangements for the transport of tubs between the shaft and screens.

Screening.—Every attention is paid to the cleaning of the pits' produce, the coal being sorted and re-sorted to provide a saleable article, and, even where a mixture of "small" and "round" (on a par with the unscreened in England) is needed, the two are usually divided and cleaned separately before being finally mixed together to be put into the truck.

The screens are all of the jigging pattern, with either side or end vibration. The Clair jigger at Montmartre is an excellent example of the counterbalance principle being applied to obviate unnecessary vibration in the screen-shed.

Cleaning-belts are either wire-woven or "plate" of the ordinary pattern, and canvas-belts are very generally used for conveying small.

Coal-washers.—A variety of washers is to be seen, as a portion of the coal at every pit is washed; for example, a Coppée washer at Roche-la-Molière, a Humboldt at Malafolie, a Biétrix at Montmartre, a Villiers and a Commentry at Méons, a Revollier at the Loire pit, and an Evrard at La Béraudière, La Péronnière, and the Loire pit.

The Coppeé washer at Roche-la-Molière, capable of treating 78 tons per hour, is a particularly fine plant, and the appliances for sorting the different classes of coal both before and after washing, with further choice of mixing as desired, are very complete. The coking coal is crushed after being washed; Carr disintegrators are in use at most of the crushing plants; briquettes in large quantities are made from the finest of the washings.

Coke-ovens.—There is a comparatively small demand for coke in this district, which accounts for the few coke-ovens seen. There are 72 retort-ovens of the old Belgian type at Roche-la-Molière, but the largest plant seen was that at the Mars pit at Méons, where there are 170 ovens. These are 19 feet 8 inches long by 2 feet 1½ inches wide (maximum width), by 5 feet 11 inches high, with vertical flues. Each oven has three charge-holes, through which coal is dropped simultaneously from three cannisters carried on one travelling bogie. The quantity put into the oven is about 3½ tons, the duration of burning being 43 hours, and the yield of coke is said to reach 78 per cent. Volatile matter in the coal is low, little more than 20 per cent.; breeze and ballast after coking are said to amount to about

7½ per cent. A coke-screening establishment handles nearly the whole of the coke made, screening and sorting it as required. An excellent coke is produced, well burnt, dense, hard, and of good appearance.

Boilers.—The more up-to-date collieries have boilers of the Büttner type, with superheaters attached, and working at a pressure of 110 to 140 pounds per square inch. At Roche-la-Molière and Méons the boilers are heated by the coke-oven gases. In some of the engineering-works the Babcock-and-Wilcox boiler seems to find favour.

Electric Plants.—The most noteworthy are the following:—At the central power-station at Roche-la-Molière, there are two Brown-Boveri-Parsons turbo-alternators, and a third will be added shortly. Each turbo-alternator is of 600 kilowatts capacity, running at 3,000 revolutions per minute, and furnishing three-phase current at 240 volts, with a frequency of 50 cycles per second. For long-distance work there are transformers to step-up to 5,000 volts.

At the Combes pit, a low-pressure steam-turbine, with a Rateau accumulator-regenerator, utilizes the exhaust-steam of the larger engines: the turbine being coupled direct to a Sautter-Harlé three-phase alternator of 185 kilowatts capacity, running at 1,800 revolutions per minute, and furnishing three-phase current at 1,500 volts, with a frequency of 60 cycles per second.

At Malafolie, there are two 250-kilowatt sets, each with a three-phase generator working at 1,000 volts and 20 cycles, both being belt-driven.

At Montmartre, there is a direct-current set of 160 kilowatts.

At Montrambert, current is supplied by a 400-kilowatt Rateau turbo-alternator, built by Sautter, Harlé & Company, and by three smaller alternating sets driven by Laval turbines of 100, 150, and 150 horsepower.

At Méons, there are two three-phase alternators, each of 152 kilowatts, and direct driven by Corliss condensing-engines: the current at 1,000 volts and 20 cycles being used for power purposes. A Laval turbine of 150 horsepower drives, by counter-shafting, two continuous-current generators supplying current at 120 volts.

At the central power-station at La Péronnière, there are three 175-kilowatt sets, supplying three-phase current at 3,000 volts and 40 cycles.

Cooling-towers and surface-condensers are to be seen at all the large electric-power stations.

Ventilating Fans.—These are generally small quick-running fans of the Mortier or Rateau type. At Méons, a duplicate set is provided for cases of emergency.

Haulage-engines.—Whatever arrangements there may be in the way of underground mechanical haulage, one failed to see a single engine for the purpose installed on the surface, and apparently there is very little done in this direction.

At the Loire colliery, two electric locomotives deal with the output of the Rambaud pit along a plane 4,200 feet in length. Each runs with a set of 25 to 30 tubs, and travels at a speed of 7½ miles per hour.

Compressed Air.—Air-compressors, built at the works of l'Horme and by Biétrix Le Flaive & Company, are chiefly of the two-stage type. One at the Mars pit is actuated by a Laval turbine of 300 horsepower, which is supplied through the medium of a Rateau accumulator with the exhaust-steam of the large engines at the colliery.

Pumps.—There are many and varied types of pumps of every description, including electrically-driven centrifugal pumps with vertical and with horizontal spindles. A Kaselowsky hydraulic pump at the Ferouillat pit at La Béraudière lifts 662 gallons of water per minute against a head of 1,492 feet.

Safety-lamp Cabins.—These are roomy and well, but not elaborately, equipped. The Marsaut, Mueseler, and Wolff lamps are chiefly used, the latter with magnetic lock and electric-lighting device.

Workmen's Bathrooms.—A commodious building is found at every colliery, providing douche-baths for the workmen, and equipped with accommodation for each man's pit-clothes being dried and aired when he undresses and changes on leaving the mine.

Sundry.—Some special features noticed were:—(*a*) Arrangements at the Combes pit at Roche-la-Molière, and at the several pits at La Béraudière, for heating the air before it enters the downcast shaft. This is accomplished by passing the air through a stack of steam-heated tubes: the main object being to guard against possible inconvenience caused by frozen water-pipes in cold weather.

(*b*) Nearly every colliery has its premises enclosed by a substantial and high wall, which no doubt tends to ensure privacy, and certainly should be a guard against petty thieving.

(*c*) The larger collieries possess extensive timber-yards, in which they store their green wood and prepare it for the pit. The Mars pit at Méons has a most elaborate timber-yard, equipped with useful lifting cranes and portable circular- and band-saws.

(*d*) Some of the quarries worked in conjunction with the pits (to provide stone for them) are very methodically laid out, that at Méons being probably unique in this respect.

(*e*) A Sturtevant fan is employed at the Gillier pit, at La Péronnière, to collect the dust circulating about the screens.

(*f*) A rope-testing machine is installed at Montrambert, and it is said to ensure good results, through providing a check on the rope-manufacturer's guarantees.

(*g*) To place trucks, as required, into the various roads under the coal-cleaning shed, mechanical transporters are invariably used. This contrivance (which is capable of carrying one truck at a time) traverses the several roads at right angles, is driven by electric motor, and can be operated by a boy. In a confined yard it economizes space, by obviating the need for long lengths of sidings above and below the screen-shed, and saves the constant expense of a shunting locomotive.

(*h*) Horses about the collieries are of a strong useful class; they are well groomed and fed, and the surface stables are kept in perfect order. In the stables the swinging partition between the stalls, advocated by Mr. W. C. Blackett,* is very frequently seen.

In concluding these short notes, I must not omit to say how much impressed I was with the very thorough arrangements made for our inspection of the various works and collieries. Every facility was afforded in this direction, and it was particularly pleasing to see the readiness with which any information was given.

* "Underground Stables," by Mr. W. C. Blackett, *Trans. Inst. M. E.*, 1902, vol. xxiv., page 483.

I was most hospitably entertained throughout my stay in St. Étienne, and I shall always have a pleasant remembrance of the uniform courtesy and spirit of good fellowship shown to me by the many friends I made during my visit.

I remain, Gentlemen,

Yours faithfully,

ARTHUR M. HEDLEY.

The CHAIRMAN (Mr. John H. Merivale) said that the members felt very much indebted to Mr. Hedley for his services as delegate and for his report.

Upon the conclusion of the meeting, the members visited the Hancock Museum of the Natural History Society of Northumberland, Durham, and Newcastle-upon-Tyne, and inspected the Loan Exhibition of Forestry, which was lectured upon by Mr. John F. Annand, Lecturer in Forestry at Armstrong College.

Mr. JOHN H. MERIVALE moved that the very best thanks of the members be accorded to Mr. Annand for his very able description of the exhibition, which he was certain they had all viewed with interest.

Mr. W. C. BLACKETT seconded the resolution, which was unanimously adopted.

Mr. JOHN F. ANNAND briefly replied.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
OCTOBER 10TH, 1908.

MR. T. E. FORSTER, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on August 15th, September 26th, and that day; together with the proceedings of the Council of The Institution of Mining Engineers at their meetings on July 29th and September 2nd.

The PRESIDENT (Mr. T. E. Forster) said that the members present would have gathered from the minutes that The Institution of Mining Engineers had entered on another phase of its career, as the headquarters would shortly be located in London. He believed that some time ago there was a proposal made that something should be done in the way of providing additional comfort and rooms for the members of the North of England Institute for reading and smoking. The Library Committee had the matter in hand, and he hoped that these advantages would be provided, and that they would add to the comfort of those members who used the rooms and attended the meetings.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr CHRISTOPHER CUNNION DAVIDSON, Mining Engineer, Hardheads, Egremont, S.O., Cumberland.

Mr. JAMES HAMILTON, Civil and Mining Engineer, Blackhills Road, Horden, Sunderland.

Mr. THOMAS ASPINALL MARSH, Mining Engineer, Leaders Buildings, Wigan.

Mr. MAX JOHN STEPHAN, Consulting Engineer, 37, South Hill Park, Hampstead, London, N.W.

Mr. Maurice Hewson Wilkinson, Colliery Manager, c/o Messrs. Mackenzie & Company, Limited, Chungking, West China, *via* Siberia, Pekin, and Hankow.

Mr. Arthur Hamilton Williams, Mining Engineer, Box House, Llanelly.

Associate Members—

Mr. Peter Norman Broughton Haggie, The Limes, Whitburn, Sunderland.

Mr. George William Nugent Hopper, The Ropery, Thornaby-on-Tees, Stockton-on-Tees.

Associates—

Mr. William Kelso, Colliery Under-manager, Blackhills Road, Horden, Sunderland.

Mr. John Lawson, Colliery Under-manager, 32, Prince Road, Tow Law, S.O., County Durham.

Mr. William Mycock, Colliery Under-manager, Blackhills Road, Horden, Sunderland.

Mr. James Paul, Assistant Surveyor, Blackhills Road, Horden, Sunderland.

Mr. James Thirtle, Master Wasteman, Grant Street, Horden, Sunderland.

DISCUSSION OF MR. ARTHUR ROSS'S PAPER ON "CIRCULATION AND HEAT ABSORPTION IN STEAM BOILERS."*

Mr. Arthur Ross (London) said that, when the paper was last discussed, the question as to the effect of the speed of the gases through the boiler was raised. He (Mr. Ross) had looked into the question, and had found that experiments had been carried out in France, the results of which might probably be of some interest to the members. They were carried out by the Northern Railway of France upon an ordinary locomotive boiler, in which, first, all the tubes were open, the number afterwards being reduced by one-half, considerable changes from 20 to 100 millimetres of water also being made in the force of the draught during each set of the experiments. The experiments tended to show that by reducing the number of tubes a more rapid circulation of gas through them, and a greater efficiency in the heating surface of the fire-box, was obtained. He (Mr. Ross) did not think that the case was exactly similar to that of the gases from coke-ovens, because, naturally, the temperature would be higher, or at any rate the calorific value would be higher, than in coke-oven gas. The fact that experiments had been carried out, showing that the more rapid movement of gases over the surface was likely to create a better absorption of the heat might also be

* *Trans. Inst. M. E.*, 1908, vol. xxxv., page 429.

of interest, as he (Mr. Ross) had not been able to demonstrate that point at the previous meeting.

Mr. Walter Robert Abel (Newcastle-upon-Tyne) said that Mr. Ross in his paper, at the very outset, intimated that one of the most certain helps towards ideal conditions in boilers was to ensure a frequent change of water in contact with the heating surface, or, in other words, a first-class circulation. This dictum, he (Mr. Abel) thought, almost every engineer would accept—particularly in the case of water-tube boilers, which were composed of parts of relatively small diameter. Sluggish circulation was often responsible for the formation of steam-pockets between the water and the plate, with consequent overheating of the tubes. In water-tube boilers a good circulation was an essential condition, as the tubes were usually not more than one-eighth of an inch thick; and it was necessary that the steam, which was generated very rapidly, should be swept away as it was formed. All well-designed water-tube boilers, therefore, had an active circulation, each particular tube having an unimpeded outlet to liberate freely all the steam generated therein. Taking the Stirling five-drum type of boiler as an example, a working model demonstrated that immediately steam bubbles were formed they entrained the water in the front bank of tubes in an upward direction, the tubes in the second bank acting as downcomers; and as the temperature, heat-absorption, and steam generation increased, the circulation was accelerated, and became rapid and continuous.

Mr. Ross had stated that Mr. G. Halliday had carried out experiments which demonstrated that the efficiency of heat absorption fell proportionately when the steam mixed with the water. This certainly did not apply to water-tube boilers.

He (Mr. Abel) had, some little while ago, conducted a number of efficiency tests on a boiler of the type referred to. When evaporating rather more than the full normal quantity of water for which the boiler was rated, the efficiency was not affected, the heat-absorption being at its highest, and there was practically no loss in efficiency with a 20 per cent. overload; but after that there was a slight falling off in efficiency as the boiler was forced and evaporation further increased, showing that rapid circulation and evaporation to a certain point increased the efficiency of heat-absorption. In the Lancashire type of boiler,

there was no doubt that efficiency would be increased by a good circulation; but he (Mr. Abel) questioned whether the Hotchkiss automatic circulator was large enough, or powerful enough in its action, to promote this efficiently, or to equalize the temperature in the large body of water below and above the flues to an appreciable extent. Perhaps Mr. Ross could give the members some information about the temperature, above and below the flues, obtained on a Lancashire boiler fitted with the Hotchkiss automatic circulator, compared with a similar boiler under ordinary conditions; also about the speed of the flow through the pipes of the Hotchkiss apparatus. He (Mr. Abel) had noticed that in the model of the Hotchkiss automatic circulator the circulation was only comparatively slow. Regarding the stresses and strains set up in Lancashire boilers by unequal temperatures, which caused leaky seams and weeping rivets, in practice these were not so serious, as it was possible to demonstrate by theory. Owing to the elasticity characteristic of the modern Lancashire boiler, trouble through this cause was reduced to a minimum. Mr. Ross in his paper submitted that circulation was not promoted by cross-tubes in furnaces—stating that, "when steam is formed the solid column of water in them is broken, and circulation is stopped."* From this opinion he (Mr. Abel) begged to differ, as he considered that, if the cross tubes were inclined somewhat vertically, the steam-bubbles would entrain the water with which they were mixed, and promote circulation to some extent from below the furnaces, which would increase proportionately with the evaporation in the tubes. Mr. Leslie Robertson, in his work on water-tube boilers, referred to some interesting experiments carried out by Mr. Yarrow on circulation in boilers and tubes, which supported this statement. At the same time, owing to the special wear-and-tear on cross-tubes, the trouble in cleaning or renewing, and the cost in case of repair, he (Mr. Abel) was of opinion that users of Lancashire boilers were well-advised in adhering to the plain-flued type.

Mr. Ross had referred in a very thorough manner to the detrimental effect of scale and oil upon the conductivity of heating surfaces. It was well known that some oils produced much more pernicious effects than others: pure mineral oil was not so destructive, neither did it retard to the same extent, the ad-

* *Trans. Inst. M. E.*, 1908, vol. xxxv., page 437.

mission of the heat to the water, as animal and vegetable oils, which were more subject to decomposition. He (Mr. Abel) had examined boilers in which he had found a considerable amount of oil, and no harm had been done; in other cases, a very small quantity of oil had caused serious overheating. He remembered inspecting a large stationary loco-undertype boiler in which some of the lubricating oil had accidentally got into the feed-water; owing to the boiler being blown out occasionally, the oily scum on the surface of the water had come into contact with, and adhered to, the sides and crown of the fire-box. This had not been noticed and removed at the time, and the result was that the crown of the fire-box had become overheated and had sagged down between the roof-bridges and stay-bolts, and bulged between the side-stays, so that disaster was only just avoided. It was of the utmost importance that oil should be thoroughly eradicated from all boiler feed-water. It was also indisputable that scale in a less degree retarded the absorption of heat by the water. The experiments conducted by Mr. J. Hirsch, and referred to by Mr. Ross, were of great interest.

Mr. J. A. G. Ross (Newcastle-upon-Tyne) said that Mr. Arthur Ross had very correctly stated that evaporation was somewhat proportionate to the speed of the flow. Natural circulation had its limits: it was something like natural ventilation in collieries—not sufficient—and they, therefore, had to resort to artificial means; and the same might be said of marine boilers. The circulation in a boiler depended on the intensity of the heat and the fierceness of the blast, and this was a matter that would be of interest in the future, as they were every day getting higher pressures, greater efficiency, and still more intensity of combustion. In the case where a specific tube immediately behind the fire-box burnt out in a day, on account of the fierceness of the blast and the high temperature, what was the cure for that? There was too great an intensity of heat, and too fierce a blast on the small surface, for the water to carry away the heat. In addition, the tube was a vertical tube, and a vertical surface was the most dangerous of all surfaces, the best surface being a horizontal one, heated internally. When the water entered the bottom of the tube it was not cold, but was ready to be changed into steam with a very trifling rise of temperature.

As soon as it entered the tube and began to ascend, the fierce blast from the fire acted upon it, and immediately a film of steam between the water and the tube was produced; that steam rose up between the water and the tube, and all the heat generated, instead of acting on the water, acted on this film of steam; the temperature of the plate therefore increased, as the steam was unable to absorb all the heat generated, and the tube was burnt out. There were two solutions to the question, one being artificial circulation, which was a common means, and the other, which was more practicable, the insertion of a baffle-plate upon the tube to mitigate the fierceness of the blast, and so save it (the tube) and thus give the rest of the boiler a chance to produce more steam. He thought that any multiplication of apparatus for circulation purposes which depended entirely upon natural circulation was of little use. He might be wrong, but if there were one hundred of Mr. Ross's contrivances along each side of the boiler, he did not think that the circulation of the water in the boiler would be increased to any extent. The contrivance had some good points, one being the collection of mud; the mud was collected without opening the boiler, but there was this difficulty—the mud had to be lifted 7 feet, and he thought that some kinds of mud could not be lifted that distance. He would like to know something about the approximate speed of natural circulation, which he did not suppose could be more than 3 to 4 feet a second, if it were that; and during the time when the water was going through the tube in the boiler at this speed, all the surface would be converted into steam; therefore he suggested that duplication of natural circulation did no good at all.

Mr. Arthur Ross (London) replying, said that Mr. Halliday's experiments demonstrated that steam mixing with water lowered the heat-absorbing power of the boiler, which was confirmed by Mr. Abel's remarks that after a 20 per cent. overload there was a falling off of efficiency. This would, no doubt, be at the time when steam more or less filled the tubes.

In reference to Mr. Yarrow's experiments, he (Mr. Ross) had carried out numerous experiments with a similar apparatus, which clearly demonstrated (1) that circulation could be and was brought to a standstill in both legs when equally heated and when steam began to form; and (2) that by continuing to apply

heat, water at and above the source of heat was displaced by steam, no matter at what angle the tubes were inclined, and that by further heating the tubes were destroyed.

These experiments and conditions approximated as nearly as possible to cross-tubes in a cylindrical boiler and to tubes in a water-tube boiler that was being forced. As a further confirmation of these conditions, reference might be made to Mr. C. W. Williams' work on *The Combustion of Coal and the Prevention of Smoke Chemically and Practically Considered*, where the type of boilers fitted in 1842 to the s.s. "Great Liverpool" were illustrated and explained as follows:—

"In the first marine boilers, the flues were made deep with narrow water spaces, usually about 4 inches wide. The object then was to combine the two essentials,—adequate length of run in the flue, with sufficient heating surface. Among the disadvantages of this arrangement of the flues was, the recurrence of injury to the plates in the region of the furnaces by becoming over-heated. Although this evil of over-heating continues to be experienced, the direct cause of it has remained without due inquiry. Its recurrence was usually attributed to neglect on the part of the fireman, or the want of sufficient water in the boiler; hence more importance was attributed to the necessity of having 'careful and experienced stokers,' than to the remedying the defective construction of the boiler itself.

"If the water indicated a level above the flues, all was considered right, and no thought was given to the possibility of its being deficient below or around them. Yet experience has shown, that although everything indicated a proper height of water in the boiler, the plates, particularly those connected with the furnaces, were, nevertheless, subject to be over-heated and injured. In such cases, if the iron was laminated, or otherwise of inferior quality, it became cracked, or burned into holes. This state of things was strikingly illustrated in the boilers of the "Great Liverpool" steam ship, on her first voyage to New York, in 1842. The engineer, observing the side plates of the furnaces constantly giving way,—some bulging and others cracked and leaking, and even burnt into holes, although there was always a sufficient height of water in the boiler, suspected something had interfered to keep the water from the plates, and with the view of testing it, introduced an inch iron pipe from the front into the water space between two of the furnaces. This at once brought the source of the evil to notice, for although the glass water-gauge always indicated a sufficient height of water within, yet nothing issued through the pipe but steam, so long as the boiler was in full action.

"This fact unmistakably showed that the over-heating of the plates was unconnected with the duties of the fireman, and was the result of insufficient circulation, depriving the deep narrow flue-spaces of an adequate supply of water. There was then, manifestly, no remedy for this continually recurring evil, and a new boiler became necessary.

"The important point then for inquiry is, Why was the plate thus left in contact with steam instead of water? There was here no apparent impediment to the steam rising to the surface. There was, however, as we shall see, extraordinary difficulty of access to the water to dislodge the steam; and, as Dr. Ure observes, it must remain, until 'forced upwards by colder and heavier atoms of water.'" *

* 1854, pages 154 to 156.

The narrow water-spaces referred to compared very closely with tubes of equal diameter, and the conditions of the water therein discovered no doubt frequently occurred in all types of boilers where the water-spaces were confined.

The remarks of Mr. J. A. G. Ross also confirmed this tendency of steam to interpose between water and the hot plate, greatly to the detriment of efficiency, as heat-vibrations would not travel into a gaseous medium so rapidly as into a liquid, so that either the plate or tube became overheated, or the heat passed on and was lost for useful purposes.

With regard to the equalization of temperatures, in a recent test of a boiler in full work for some days the usual difference between top and bottom was from 90° to 100° Fahr.; but after the Hotchkiss circulator was put to work, the difference was only 6° Fahr.; the temperatures being taken by thermometers immersed in cups containing mercury. Only one circulator was attached to this boiler; more than one to each boiler was not necessary. The fact that mud rose 7 feet into the Hotchkiss circulator was due to the speed of the circulation, aided by the fact that the grains of deposit just left behind by the evaporated water were at first extremely small, the agitation of ebullition driving them to the steam surface, where they crystallized, or grew into larger grains by congregation, and subsided. The Hotchkiss collected them before they became large and heavy, so that the mud blown out of the reservoir was wonderfully fine and soft. This scum explained much of the trouble some boilers gave through priming: it formed a blanket on the water-surface, and steam could not disengage itself freely, with the result that there was an increased pressure of accumulated steam under the scum before it could free itself; and when that moment arrived, there was a considerable upheaval of steam and water. These were conclusions drawn from numerous careful observations and tests upon boilers in actual work.

As to the speed of flow, it had never been determined, being an extremely difficult matter; but supposing that Mr. J. A. G. Ross's estimate of 3 to 4 feet per second were adopted, that rate of flow in a 3-inch pipe meant 3,300 to 4,380 gallons per hour, sufficient to turn over all the water in a large Lancashire boiler well within an hour, but the flow in the Hotchkiss circulator was accelerated probably three or four times that rate.

It was of no moment whether the fresh feed-water or the water already in the boiler was circulated; the point aimed at was to keep the heating-surface thoroughly wet, constantly washing away the steam bubbles and presenting the solid water to the metal. When this perfect condition could be assured, it would be possible to evaporate safely huge quantities of water per square foot of heating surface; fires will become fiercer, boilers smaller, and economy greater.

Mr. Ugo Bagnoli's paper on "Repairing Leaky Seams" was read as follows:—

REPAIRING LEAKY SEAMS.

By UGO BAGNOLI.

Several methods of stopping leaks in boilers and furnaces are doubtless familiar to the members, but a brief description of a device used successfully in repairing the furnace of a little locomotive may be of interest.

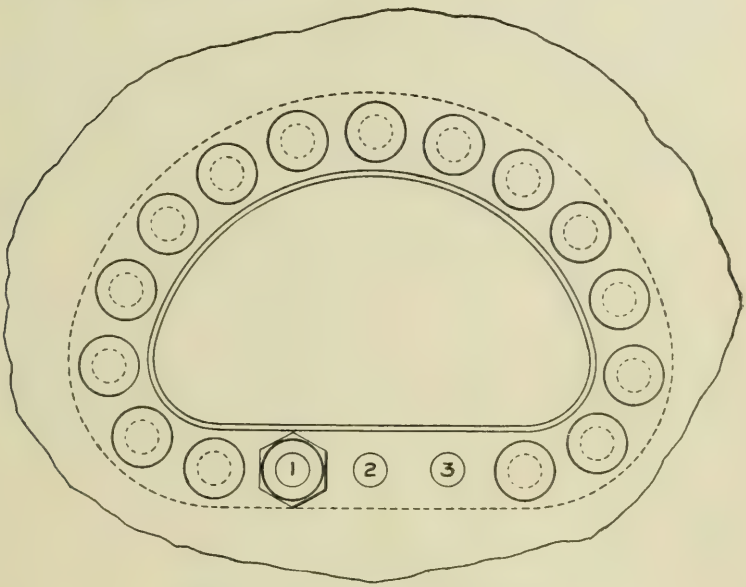


Fig. 1.—Portion of Boiler Repaired.

Fig. 1 represents the part of the boiler repaired. After caulking had proved not only unsuccessful, but had nearly destroyed the copper plate round the rivets, the application of Smooth-on cement was experimented with. To overcome the difficulty of forcing the cement well into the seam, the device illustrated in Fig. 2 was put in place in the first hole (No. 1, Fig. 1); the bored hole of the bolt was filled with the cement, which was then forced into the interior with the iron piston,

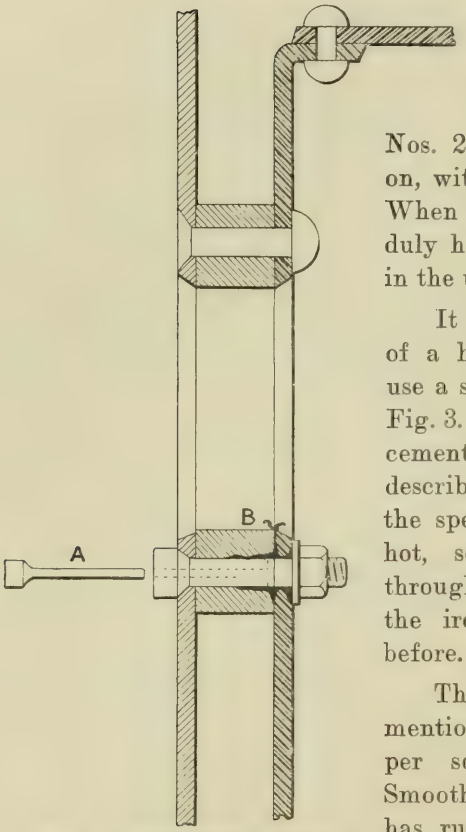


FIG. 2.—APPARATUS FOR FORCING IN THE CEMENT.

A (Fig. 2), some cement coming out at B. The same operation was carried out at holes Nos. 2 and 3 (Fig. 1), and so on, with the same bolt-pump. When the rivets were ready and duly heated, they were riveted in the usual way.

It is convenient, in the case of a highly corroded plate, to use a special rivet, as shown in Fig. 3. The seam is filled with cement with the bolt-pump, as described, and then riveted with the special rivets. When still hot, some cement is forced through the bored rivets with the iron piston, as explained before.

The pressure on the above-mentioned boiler is 160 pounds per square inch, and since Smooth-on cement was used it has run for over two months without any signs of leak.

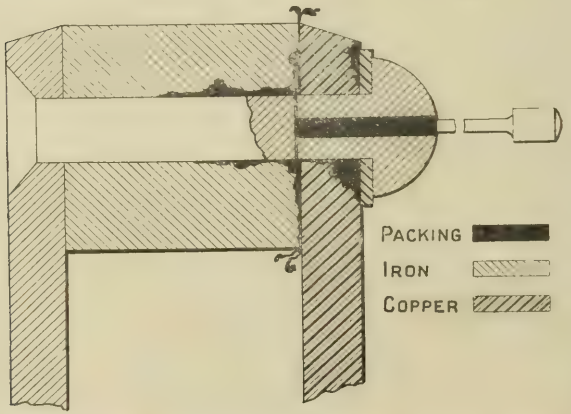


FIG. 3.—APPARATUS FOR FORCING IN THE CEMENT, SHOWING SPECIAL RIVET FOR CORRODED PLATES.

Mr. Simon Pedelty (Broomhill) wrote that the sketch appeared to be that of a firedoor-opening for a locomotive. In his experience, the chief trouble was generally caused by the burning away of the heads of the bottom row of rivets. He was afraid that this could not be remedied by the method described by Mr. Bagnoli, and he (Mr. Pedelty) would prefer to put in new rivets.

Perhaps the author would inform him whether, when the pump-bolt had been fixed in position and screwed up, the cement was allowed to set before the bolt was released, because it appeared to him (Mr. Pedelty) that if that were the case the spring on the plate would cause it to leave the cement, and there was a possibility that the plate might not join with the cement when riveted up. The fracture would also need to be of a good size to allow of the cement running in, unless the latter was in a very liquid state.

Referring to Fig. 3, it would be interesting to know by what means the hole was put into the rivet while hot, as it would be almost impossible to drill the hole by the ordinary method. Also what effect had the hammering-up of the rivet upon the smaller or radiating cement-hole, which he presumed was drilled into the rivet before it was inserted.

Mr. John McLaren (Leeds) wrote that Mr. Bagnoli described a very interesting, ingenious, and apparently successful, method of stopping a leaky seam, but he (Mr. McLaren) did not think that it had any practical features to recommend it for general use. A much better plan would have been to cut the rivets out entirely, and put in new ones, which would support the plate whilst being caulked and made tight in the ordinary way. Drilling up the centre of the rivet and putting in the holes radiating from the centre to the outside would reduce the strength of the rivet to such an extent as to render it too weak for its work. All practical men knew that it was much better to rely upon caulking a seam than to depend on any kind of cement for keeping the joint tight.

Mr. Henry Lawrence (Newcastle-upon-Tyne) wrote that the method described by the author was both interesting and ingenious. Mr. Bagnoli had stated that the pressure was 160 pounds per square inch, and that the furnace had run over two

months without any sign of a leak; but he (Mr. Lawrence) did not think that the joint would last, or that it would satisfy a Government inspector or a boiler insurance company.

Mr. Arthur M. Terry (Gateshead-upon-Tyne) said that a very interesting subject had been introduced by Mr. Bagnoli, who, he regretted, was not present at the meeting. It would be interesting to know whether the fracture in the copper plate extended from the rivet-hole to the end of the plate or not, and why the holes through the firehole-ring and steel and copper plates were not drilled and rhymered, and new rivets inserted. Would not cement in a joint subject to high pressure be liable to blow out? Was the cement, when put in, in a liquid or plastic condition, and what means were taken to prove that it had actually followed the joint and had come through the plating at the bottom of the firehole-ring as shown in Fig. 3.

He (Mr. Terry) would further like to know whether the design of firehole-ring was peculiar to the engine, or whether it was one usually adopted for the boilers of Italian locomotives; also whether it was the usual practice to chamfer off the edges of the two plates to the level of the firehole-ring, as shown in Fig. 3, or to leave a lip for fullering as shown in Fig. 2? Was any design of plate protector for the firehole-rings generally contemplated or in use? It would be of interest if Mr. Bagnoli would state the class of engine (whether tank or tender), and give the diameter of the cylinders and the length of stroke.

It did not appear that percussion alone on the bolt-pump plunger would force the cement into the position shown in Figs. 2 and 3. Was the result obtained by percussion only, or was the bolt tapped and the plunger chased, and the cement forced in by screw pressure?

The President (Mr. T. E. Forster) said that the author would have an opportunity of replying to the discussion, and the additional information would no doubt be of value. He had pleasure in proposing a vote of thanks to Mr. Bagnoli.

The vote of thanks was carried unanimously.

Mr. J. G. Thompson's paper on "The 'Bold' Box-controller and Box-switch" was read as follows:—

THE "BOLD" BOX-CONTROLLER AND BOX-SWITCH.

By J. G. THOMPSON.

The "Bold" box-controller and box-switch, which were designed by the writer some years ago, for use underground, and constructed in the colliery-shops, have proved successful.

"*Bold*" *Box-Controller.*—In the "Bold" controller (Figs. 1 and 2, Plate VII.), the mooring-posts, *A*, are set vertically, sunk into roof and warrant, and kept at the correct distance apart by through-bolts, B^1.

At the height of the centre of gravity of the boxes, an iron strap, *B*, is passed across the face and two sides of each of the mooring-posts. The straps and posts are drilled to take mooring-bolts, *C*, which secure the flattened ends of Vignoles rails, *D*, to the post.

The rails, which are of about 45-pound section, are flattened at both ends, the front ends drilled for the mooring-bolts, *C*, and the back ends turned in to assist in taking the thrust of the renewable rubbing-blocks, *E*, made of deals, which are secured by bolts carried through the flanges. The back ends of the rails are further drilled, one to secure it to the L rail, *F*, the other to carry the socket for the head of the adjusting screw, *G*. The L rail, through which the controlling pressure is applied, is made of a piece of worn bull-head rail of about 80-pound section.

The web is cut out of the top, so as to form a jaw for the reception of the connecting-rod, and at the other end a slot is cut in the web to receive a straight piece of rail of similar section. The L rail is passed under the box-road immediately below the rails, and is free to adjust itself sideways as the boxes may require.

The straight rail is swaged down at the bottom end to fit loosely in the slot of the L rail, and is secured by a cottar. It is drilled at the necessary height to take the 1½-inch diameter adjusting-screw, *G*, which works in a special nut, *H* (Fig. 2,

Plate VII.), riveted to the rail. The web at the top end of this rail is cut out to form jaws for the pressure-lever, *I* (Fig. 2, Plate VII.).

The pressure-lever, *I*, is cranked at an angle less than a right-angle, thus permitting the connecting-rod, *J* (Fig. 2, Plate VII.), which is bent and strengthened for the purpose, to be carried far enough past the centre to form a lock, and, in passing to the centre, to exert pressure so great that considerable force is needed to move the adjusting-screw when the pressure-lever is closed on a box.

Controllers worked by a screw have been in use for many years, but their action is slow, whereas in the Bold controller the pressure is put on and released rapidly by means of the lever.

The Bold box-controller can be adapted for use above-ground, by placing the through-bolt below the rail level, or through the mooring-posts, well above the box, the posts being moored by long bolts or struts to take the pull or thrust due to the movement of the box.

"Bold" Box-switch.—The "Bold" switch (Figs. 3 and 4, Plate VII.), acts on the inside of the wheel-flanges. The plate, *K*, carries an angle-iron deflector, *L*, riveted near the centre, one end being bent to form the other deflector. The distance outside the tips of the deflectors must be, as nearly as possible, equal to the width between the wheel-flanges. If it is necessary to run boxes in either direction, the deflectors must be extended and bent as shown by the dotted lines.

The plate is carried in an iron trough, *M*, with a short cover-plate, *N*, nailed to the sleepers, and passes immediately below the near rail. Its outer end is bent up so as to work over the lever, *O*, and is slotted to take the lever-pin, *R*.

The lever, *O*, has a handle, frequently worked by the foot, and turns on a pin, *P*, welded into itself, and lightly riveted to make a connection with the base-plate, *Q*. A second pin, *R*, is riveted into the lever, and engages a slot in the deflector-plate. The distance between these pins regulates the throw of the switch; and as it is only, say, 1 inch, there is some difficulty in getting the two into the lever.

The base-plate, *Q*, is bent on the inside edge so as to secure a good hold on the sleepers, to which it is fastened by wooden screws. The main pin, *P*, of the lever turns in it, and

"BOLD" BOX-CONTROLLER.

FIG. 1.—PLAN.

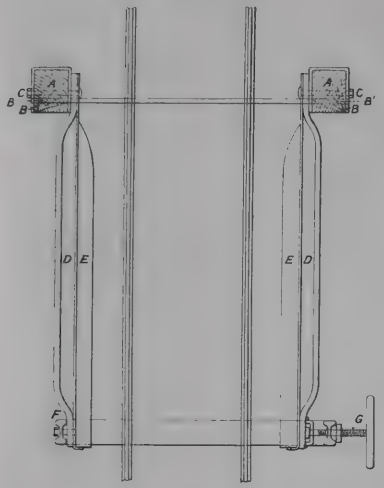
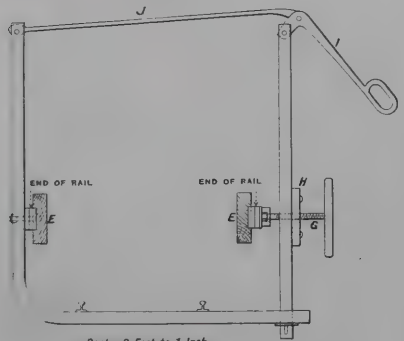


FIG. 2.—ELEVATION.



Scale, 2 Feet to 1 Inch.

"BOLD" BOX-SWITCH.

FIG. 3.—PLAN.

REFERENCES TO FIGS. 1 AND 2.

- *A* MOORING-POSTS.
- *B* IRON STRAP.
- *B'* THROUGH-BOLTS.
- *C* MOORING-BOLTS.
- *D* FLANGE RAILS.
- *E* RENEWABLE RUBBING BLOCKS
- *F* L RAILS.
- *G* ADJUSTING-SCREW.
- *H* SPECIAL NUT.
- *I* PRESSURE-LEVER.
- *J* CONNECTING-ROD.

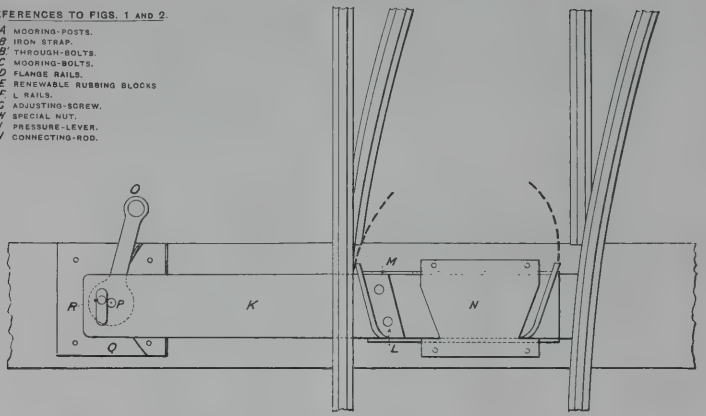
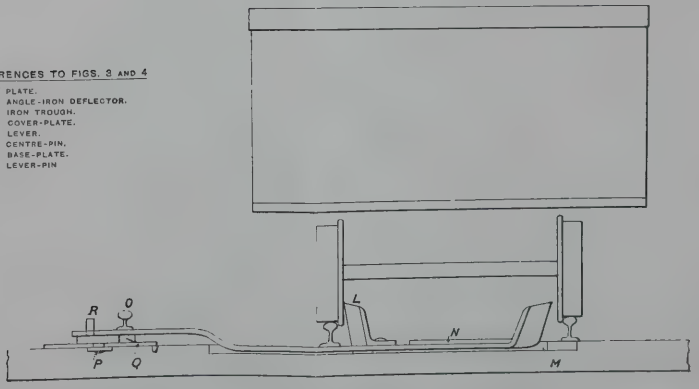


FIG. 4.—ELEVATION.

REFERENCES TO FIGS. 3 AND 4

- *K* PLATE.
- *L* ANGLE-IRON DEFLECTOR.
- *M* IRON TROUGH.
- *N* COVER-PLATE.
- *O* LEVER.
- *P* CENTRE-PIN.
- *Q* BASE-PLATE.
- *R* LEVER-PIN



Scale, 1 Foot to 1 inch.

The North of England Institute of Mining & Mechanical Engineers Transactions 1888 1889

And^w Reid & Comp^y L^td Newcastle upon Tyne

the movement of the lever, about 185 degrees, is determined by slitting the edge of the plate and turning it up. This movement, also, going past the centres, forms a lock on the switch. A re-arrangement of the switch has been made to adapt it to three-throw points. The lever in this case works under a guard in which is a notch corresponding to the middle position. A spring under the lever lifts it into the notch when the pressure is taken off the handle.

Another rearrangement, for dealing with empties from the screens, consists in fixing a long vertical lever and connecting-rod to the deflector-plate, enabling a lad to easily deal with ten boxes per minute. The long lever can be locked, if necessary, by means of a notch.

The advantages arrived at were an easily-worked, self-locking switch, not liable to be clogged up with dust or grease, and able to be moved over rapidly whilst boxes were passing close together. The short length of the deflectors (6 inches) enables these to be gained.

Mr. G. H. Stanley's "Note on the Effect of an Igneous Dyke on a Natal Coal-seam" was read as follows:—

NOTE ON THE EFFECT OF AN IGNEOUS DYKE ON A NATAL COAL-SEAM.

By G. H. STANLEY.

In the St. George's colliery, Hatting Spruit, Natal, an igneous dyke, 22 feet thick, cuts through the coal-seam, as usual spoiling the coal in contact, and for some distance on either side.

In order to ascertain to what distance the prejudicial effect of the dyke had been exerted, samples of the coal were taken by the manager, Mr. W. Taylor Heslop, at the contact and at intervals of 3 feet away from it, at right angles. These samples were submitted by the writer to proximate analysis, in the usual manner, for the determination of volatile matter, fixed carbon, etc.

No. of Sample.	Distance from Dyke.	Results per cent.						Ratio between Volatile Matter and Fixed Carbon.	Nature of Coke.
		Moisture.	Volatile Matter, less Moisture.	Carbon dioxide (CO_2).	Volatile, other than CO_2.	Ash.	Fixed Carbon.		
	Feet.								
1	0	0·80	12·43	11·70	0·73	29·66	57·11	0·012	Appearance same as coal.
2	3	0·80	14·59	*10·50	4·09	30·96	53·65	0·077	Do.
3	6	1·20	9·54	5·05	4·49	15·87	73·39	0·061	Do., but very slightly fritted.
4	9	1·60	7·40	Undetermined; not apparent qualitatively.	7·40	25·08	65·92	0·112	Do.
5	12	1·46	19·98		19·98	12·99	65·57	0·304	Caked, compact, but rather soft.
6	15	1·34	24·57		24·57	7·67	66·42	0·369	Caked, swollen, harder.
7	18	1·48	27·85		27·85	10·21	60·46	0·460	Do.
8	21	1·48	28·37		28·37	6·17	63·98	0·443	Do.
9	24	1·64	27·85		27·85	6·44	64·07	0·436	Do.
10	27	1·70	28·34		28·34	6·00	63·96	0·442	Do.

* The author is indebted for this determination to his colleague, Prof. J. A. Wilkinson.

The loss of weight on heating, however, was so unexpectedly large in the samples taken near the dyke, although little or no flame was observed, that these samples were next examined for carbonates, which were found to be present in considerable amount, thus accounting for the loss of weight.

The table on page 220 gives the results of the analyses, and these show that the coal has evidently been infiltrated by mineral solutions, which have deposited carbonates; access being obtained, doubtless, along the contact.

It will be seen, further, that 18 feet away from the contact the coal is practically unaltered.

Mr. William Taylor Heslop (Hatting Spruit, Natal) wrote that the occurrence of igneous dykes and sheets was so extensive in the Natal coal-fields that any information showing their effects on the coal-seams was of especial value.

Although the total area of the coal-bearing ground was very extensive, the areas containing coal unaffected by igneous action were comparatively limited—probably not more than from 25 to 30 per cent. of the coal-bearing area.

The market for bituminous coal was extensive. In addition to the bunkering trade at Durban, coal was now being exported as cargo to Cape Colony, Madagascar, Mauritius, Bombay, Ceylon, Singapore, and the east and west coasts of Africa. The market for anthracite coal was insignificant, and was confined to a few small producer-gas plants. The coking effects of igneous dykes and sheets, therefore, made large areas of coal commercially valueless.

In a paper on "The Coal-fields of Natal" he (Mr. Heslop) had stated that, "roughly speaking, the coal is found unaffected at a distance from the dyke, equal to the thickness of the dyke."* Mr. Stanley's assays showed that the coal was unaffected 18 feet distant from a dyke 22 feet thick, or 81·8 per cent. of the thickness of the dyke.

This was probably fairly representative as far as Natal was concerned. It could hardly be expected that the distance affected should bear a uniform ratio to the thickness of the igneous body, as in some cases dykes occurred which passed

* *Trans. Inst. M. E.*, 1899, vol. xviii., page 416.

through the coal-seam, but hardly reached the surface; whilst in other cases they formed the feeders to extensive horizontal sheets or sills, and the flow of molten rock, and consequent heating effect, must have been of much longer duration.

The determination of combined carbonic-acid gas illustrated the necessity for care in analytical determination. Where the proximate analysis only was obtained, it was absolutely necessary to have information as to the nature of the coke obtained, otherwise the mere determination of volatile matter might be very misleading. Water which had passed through Natal dolerite sheets or dykes was generally alkaline, containing sulphates of lime and soda, and carbonates of lime and soda. Probably some of these ingredients had permeated the coked coal—in proximity to the dyke—from which Mr. Stanley's samples were taken.

A sample of Natal coal, of which the proximate analysis showed 20 per cent. of volatile matter, might be any one of three classes of coal, namely, (*a*) a bituminous coal with coking qualities; (*b*) a semi-bituminous coal, from a district where the normal proportion of volatile hydrocarbons was 30 per cent., which had been robbed of 10 per cent. of its volatile hydrocarbons by igneous action, and by virtue thereof had lost its coking qualities; or (*c*) an anthracitic coal, which had lost its hydrocarbons through igneous action, and had had them replaced by combined carbonic-acid gas—which was volatile matter but not volatile hydrocarbons, as shown by the interesting determinations of Mr. Stanley.

On the motion of the PRESIDENT, a vote of thanks was unanimously passed to the writer of the paper.

Mr. G. H. STANLEY's "Note on a Deposit of Sulphur in a Colliery Water" was read as follows:—

NOTE ON A DEPOSIT OF SULPHUR IN A COLLIERY WATER.

By G. H. STANLEY.

Some years ago, the writer was asked by Dr. P. Phillips Bedson, of Armstrong College, Newcastle-upon-Tyne, to examine a peculiar deposit, which had been found at Wheatley Hill colliery, in a place into which—as far as the writer remembers—water was being drawn off from an adjacent old and drowned working. The results, however, do not appear to have been placed on record, and may be of interest.

The deposit was a greyish slimy mass, somewhat suggestive of yeast in appearance; on drying, it hardened, and on qualitative examination was found to contain sulphur, iron, sodium, and probably organic matter. On heating, it melted and ignited, the sulphur burning away.

The amount of mineral ash left on burning was 5 per cent.; and, of the dried material, 90·2 per cent. was soluble in carbon bisulphide and was recovered as crystalline sulphur on evaporation; the deposit would appear to consist chiefly, therefore, of some colloidal form of sulphur.

A sample of the water from which it had been deposited was then examined, and found to be strongly alkaline, and contained so much carbonate in solution that it effervesced on the addition of acid.

The following table gives the result of analysis:—

	Parts per 100,000.
Total solids, dried at 212° Fahr. (100° Cent.)	469·60
Free ammonia	0·22
Albuminoid ammonia	0·02

The analysis of the solids residue is as follows:—

Silica (SiO_2)	1·40	Lime (CaO)	3·28
Chlorine	182·01	Magnesia (MgO)	4·42
SO_4	21·58	Sodium (Na)	181·05
Iron-oxide and alumina	traces	Carbon-dioxide, etc. (by difference)	75·86

This water contained in solution chiefly sodium chloride and small quantities of sodium carbonate and sodium sulphate.

A bacterial examination by Mr. Greig gave negative results, and probably the explanation of the formation of the deposit is purely chemical.

It would seem most likely that the sodium-salt originally present was a chloride, and that this in contact with decomposing pyrites in the old workings became partly converted to sulphide, as happens on the Rand with cyanide-solutions in contact with pyritic material from old stopes.

Later on, and after escaping from the old workings, this sodium sulphide in the presence of air became oxidized to thiosulphate and sulphate, depositing sulphur, as a "hypo" solution does on standing; and becoming alkaline through the formation of caustic soda, as thiosulphate silver-leaching solutions do, it absorbed carbon dioxide from the air, forming sodium carbonate.

The reactions possibly include the following, but, of course, need experimental confirmation, although they apparently furnish a satisfactory explanation of the presence of the various bodies found:—

(1) $2NaCl + FeS_2 = Na_2S + S + FeCl_2$
$2FeCl_2 + 2CaCO_3 + 3H_2O + O = Fe_2(OH)_6 + 2CaCl_2 + 2CO_2$

(2) $2Na_2S + H_2O + 2O_2 = Na_2S_2O_3 + 2NaOH$
$Na_2S_2O_3 + O = Na_2SO_4 + S$
$2\,NaOH + CO_2 = Na_2CO_3 + H_2O.$

Prof. P. Phillips Bedson (Armstrong College, Newcastle-upon-Tyne) wrote that he was glad that Mr. Stanley had placed on record the results of his examination of the deposit found at Wheatley Hill colliery, which had been brought under his (Prof. Bedson's) notice by the late Mr. M. Walton Brown. Mr. Stanley's conjecture as to its origin was correct, and his explanation of its formation appeared to him (Dr. Bedson) satisfactory. Some little time before this Wheatley Hill deposit had been brought to his (Dr. Bedson's) notice, he had examined a somewhat similar deposit in waters from old workings in a colliery; the deposit was, however, of a slimy nature and appeared to have an organized structure, and contained no free sulphur. The absence of free sulphur distinguished it from the deposit described by Mr. Stanley; still, the water in which it occurred contained a quantity of sulphuretted hydrogen.

Mr. W. B. Wilson, Jun. (Usworth), wrote that the deposit and the water examined by Mr. Stanley were collected by him (Mr. Wilson) on January 15th, 1901.

The water was delivered through a bore-hole, and when first relieved from pressure effervesced and gave off sulphuretted hydrogen. The sample analysed by Mr. Stanley had probably lost a large proportion of the gases dissolved under pressure, and therefore what he (Mr. Wilson) considered to be the main origin of the sulphur deposit escaped the author's notice.

The sulphuretted hydrogen in solution when exposed to the air would be oxidized and the sulphur would be deposited. The only reaction given by Mr. Stanley to account for the deposition of sulphur was

$$Na_2S_2O_3 + O = Na_2SO_4 + S.$$

This formula showed the same amount of sulphur remaining in solution in the form of sodium sulphate as had been deposited as sulphur. Mr. Stanley showed by his analysis that the amount of sodium sulphate remaining in solution was not large.

In addition to the reaction expressed by the formula:

$$Na_2S + H_2O + 2O_2 = Na_2S_2O_3 + 2NaHO,$$

he (Mr. Wilson) would suggest that the following was probable, assuming that sodium-sulphide was present:—

$$Na_2S + H_2S = 2NaHS.$$

The presence of the sulphuretted hydrogen was proved by exposing lead acetate test-papers, and he would like to draw attention to the extreme delicacy of this test.

At one time the quantity of sulphuretted hydrogen given off was such, that, when thoroughly mixed with 12,000 cubic feet of air per minute, it turned a test-paper light brown in one hour. This mixture had no noticeable effect on young lads working in it for 9 hours each working day, and, therefore, the percentage detected must have been extremely small; much below a dangerous percentage.

Drs. Thomas Oliver and J. S. Haldane had recently reminded them of the deadly poisonous properties of very small percentages of this gas.

A vote of thanks was unanimously passed to the writer of the paper.

SAFETY-LAMP FOR DETECTING SMALL QUANTITIES OF INFLAMMABLE GAS.

Mr. A. L. Steavenson (Durham) said that in 1876 he had read a paper to the Institute "On an Improved Method of Detecting Small Quantities of Inflammable Gas."* At the present time, when it had been demonstrated that explosions of dust were greatly promoted by very small additions of gas, the question of the presence of these small quantities had become of added importance. His scheme was to use a dark-blue or pot opal piece of glass to look for the well-known cap on the flame of the safety-lamp, which thus became much more distinctly visible. He had recently been shown a lamp marked "Patent applied for," which had a blue glass annealed to the usual white glass, but this was quite unnecessary: all that was required was that the examiner should carry a bit of blue glass in his pocket, and no patent could prevent him from doing this.

---

* *Trans. N. E. Inst.*, 1877, vol. xxvi., page 133; vol. xxvii., page 65.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
DECEMBER 12TH, 1903.

MR. T. E. FORSTER, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on November 28th and that day.

The following gentlemen were elected, having been previously nominated :—

MEMBERS —

Mr. ALFRED ATKINSON, Mechanical Engineer, Clarke, Chapman & Company, Limited, Victoria Works, Gateshead-upon-Tyne.

Mr. JOHN HENRY CHILCOTE BROOKING, Electrical Engineer, 4, Moorfield, High West Jesmond, Newcastle-upon-Tyne.

Mr. JOSEPH STANLEY COWELL, Colliery Manager, Vane House, Seaham Harbour, S.O., County Durham.

Mr. GEORGE FERGIE, Mining Engineer, Copiapó, Chile, South America.

Mr. WILLIAM HARLE, Colliery Manager, Bowburn Colliery, Coxhoe, S.O., County Durham.

Mr. JAMES AUGUSTUS HOOPER, Mechanical Engineer, Cannop, Coleford.

Mr. JAMES JOSEPH HUNTER MCCANN, Engineer, 10, Station Terrace, Stockton-on-Tees.

Mr. JUNJIRO NAGAZUMI, Mining Engineer, Japanese Embassy, London.

Mr. HENRY NETTLE, Engineer, Tremayne House, Camborne.

Mr. THOMAS HENRY RIGBY, Mining Engineer, Leader's Buildings, King Street, Wigan.

Mr. WILLIAM ROCHESTER, Colliery Manager, Ryton Barmoor, Ryton, S.O., County Durham.

Mr. WILLIAM ARTHUR RYAN, Manager, Lonely Gold-mining Company, Lonely Mine, Private Bag, P.O., Bulawayo, Rhodesia, South Africa.

Mr. JOHN WATSON, Colliery Manager, Outtrim Colliery Office, Victoria, Australia.

Mr. FREDERICK WILSON, Colliery Manager, Hebburn Colliery, Hebburn, S.O., County Durham.

ASSOCIATE MEMBERS—

Mr. ALGERNON PERCY AUGUSTUS DE STRZELECKI, 43, Fern Avenue, Newcastle-upon-Tyne.

Mr. HUGH RUSSELL WILSON, 50, Langholm Crescent, Darlington.

ASSOCIATES—

Mr. JAMES HESLOP, Surveyor, Stobswood Colliery, Acklington, S.O., Northumberland.

Mr. JOSEPH WILLIAM KIPLING, Colliery Under-manager, 1, Station Road, West Cornforth, S.O., County Durham.

STUDENTS—

Mr. GEORGE PRIMROSE KENNEDY ARMSTRONG, Mining Student, The Elms, Gosforth, Newcastle-upon-Tyne.

Mr. VINCENT EVANS, Mining Student, Bron Hendre, Hastings.

Mr. TOM EDWARD HULL, Mining Student, 11, Clarence Terrace, Regent's Park, London, N.W.

Mr. JOHN LINTON SCOTT, Mining Student, Oak Bank, Wetheral, Carlisle.

Mr. WILFRED WALTER VARVILL, Mining Student, 12, Eldon Place, Newcastle-upon-Tyne.

SUBSCRIBERS—

Messrs. CROMPTON & COMPANY, LIMITED, Salisbury House, London Wall, London, E.C.

SAFETY-LAMP FOR DETECTING SMALL QUANTITIES OF INFLAMMABLE GAS.

Prof. HENRY LOUIS (Newcastle-upon-Tyne) said that at the last meeting a statement was made by Mr. A. L. Steavenson to the effect that he had many years ago advocated the use of a piece of blue glass for seeing caps.* He (Prof. Louis) had been carrying that idea rather further, but working on slightly different lines, by making use of a double convex lens of blue glass, about $1\frac{1}{4}$ inches in diameter, magnifying three to five times, and his experience was—and he thought the President would bear him out—that a very slight cap was more clearly seen through a blue glass lens like that than by the naked eye. He was inclined to think that such a lens might be of use to the older men in testing for gas in mines, and he brought the idea before the members in the hope that others would try the device, and see whether it was of any real use in practice, as he was inclined to hope that it might be.

---

* *Trans. Inst. M. E.*, 1908, vol. xxxvi., page 226.

DISCUSSION ON THE UNDERGROUND FIRE AT HAMSTEAD COLLIERY.*

The President (Mr. T. E. Forster) remarked that the Hamstead fire was one which had caused a great deal of excitement among the public generally. The men were shut in, and a good deal of time was taken up in trying to get at them, until operations were finally abandoned.

Mr. C. C. Leach (Seghill) said that he would like to know of what benefit rescue-apparatus had been in connexion with the fire.

Mr. W. C. Blackett (Sacriston) said that he would like to say one or two words about the report, which he thought was a very able record of the disaster, and he approached any criticism of it with a considerable amount of trepidation, and more perhaps in the light of seeking for information than otherwise.

The first point that struck him was the conclusion that seemed to have been arrived at, that there had been a breach of the Act because the winding-engine had broken down. Mr. Redmayne called particular attention to this fact,† discussed it from a legal point of view, and came to the conclusion that a technical breach of the Act had been committed.‡ He (Mr. Blackett) had looked very carefully into the Act, and it did not seem to him that such a conclusion could be upheld. To commence with, Mr. Redmayne dealt with the matter as if the shaft were not available, and mixed up the two questions of shaft and apparatus as being the same thing. The shaft was certainly available for use, but what was not completely available was the engine. Mr. Redmayne stated that "under Section 18 (iii) (*b*) it is provided that the Secretary of State may exempt any such mine when 'one of the shafts or outlets of which has become, by reason of some accident, unavailable for the use of the persons employed at the mine,'"§ and he drew attention to the fact that no exemption was applied for. But the time when exemption should be applied for was when a shaft was not avail-

* *Report on the Causes of and Circumstances attending an Underground Fire which occurred at Hamstead Colliery, on 4th March, 1908*, by R. A. S. Redmayne, 1908 [Cd. 4231].

† *Ibid.*, page 7, paragraph 10.

‡ *Ibid.*, page 8, footnote.

§ *Ibid.*, page 8.

able, and the shaft in question was available all the time. It was the engine that was in trouble, and because an engine broke down for a time, it seemed to him most unreasonable, and more than unlikely, that any manager would be held to have committed a breach of the Act. They were in a very perilous condition indeed if "constantly available for use" was to be implied to mean that an engine must not break down. This was an unreasonable view of the Act, and would not, in his opinion, be upheld by any court of law.

Another point was that, although the accident happened about 5 or 6 p.m., at 7·30 p.m. Mr. M. W. Waterhouse, the manager, was able to go down the shaft.* Mr. Waterhouse arrived at the colliery about 7·30 p.m., and, immediately on arrival, decided that it was impossible to descend through the upcast or No. 2 shaft. He made enquiries and communicated with H.M. Inspector of Mines, and at 8·45 p.m. a further and partially successful attempt was made to descend No. 1 shaft. This was the shaft that was alleged by Mr. Redmayne to be unavailable for use, and yet three hours afterwards the manager went down. One cylinder of the engine appeared never to have been out of working order at all, and whether they managed with one cylinder or not, he did not know; but, although this was urged to be a technical breach of the Act, they found the manager actually going down this shaft three hours after the accident. Perhaps they might have had some explanation of that.

Another point upon which he would like information was with regard to the reversing of the ventilation.† Mr. Redmayne gave the views of Mr. Hugh Johnstone (H.M. Inspector of Mines), and it was held that those concerned had all considered that to attempt to reverse the ventilation by the fan would have produced a dangerous strain on the fan; that is to say, had they made a communication to the downcast shaft, thrown the upcast shaft open, and then attempted to pull the air, by means of the fan, up the downcast, that the strain of reversing the ventilation would have been overwhelming and the fan would

* *Report on the Causes of and Circumstances attending an Underground Fire which occurred at Hamstead Colliery, on 4th March, 1908*, by R. A. S. Redmayne, 1908 [Cd. 4231], page 10.

† *Ibid.*, page 15.

not have been able to bear it. That he (Mr. Blackett) could not understand. He should have thought that, if the fan were going to have any extra strain thrown on it at all, it would have been by giving it air more easily, throwing open, say, the separation doors, and allowing a big load of air to go through by centrifugal force; but to take air off the fan and allow it to run, as it were, in vacuum, would actually ease the strain and not increase it at all. That was a problem which, he had no doubt, some of the professors or Mr. Redmayne himself would be able to elucidate.

Perhaps the most interesting point of all was the statement made by Mr. Redmayne that "other possible means of reversing the air-current of the mine may suggest themselves, such as covering over the top of the upcast shaft until the heat of the fire at the bottom of the downcast had induced reversal of the air; but these means have only to be considered for a few minutes in order to realize their danger or inutility. Nor was it a time to indulge in rash experiments in mine ventilation."* He (Mr. Blackett) thought that, if ever there was a time to indulge in experiments, it was at such a stressful time as that. Why did Mr. Redmayne say that covering up one shaft was only to be considered for a few minutes, in order to realize its danger and inutility? Since reading that statement, he (Mr. Blackett) had come to the conclusion that he did not know as much about accidents of this kind as he ought to know, and he would like the point explained, so that he could understand it, as it seemed to him that it was the only thing that could have saved the men's lives. He did not for a moment say that if he had been in the position of the unfortunate manager of the colliery he would have done it, because there was a certain stress of circumstances when confronted suddenly with an emergency of that kind, and one could not guarantee the ability to decide at once upon doing that which one would do when calmly thinking of it afterwards. But here they had a fire at the bottom of the downcast shaft, a fire that they had failed to get at and extinguish, and the great danger was that the products of that fire would get into the ventilation current, travel round with it, and suffocate the men. How could one immediately

* *Report on the Causes of and Circumstances attending an Underground Fire which occurred at Hamstead Colliery, on 4th March, 1908*, by R. A. S. Redmayne, 1908 [Cd. 4231], page 16.

prevent that? They could not get at the fire, and they could not easily and quickly reverse the ventilation. Well, to stop at once a body in motion, you did not apply anything very elastic to it; and it seemed to him that the only way would be to block the air-current there and then. He would have either stopped all air from going into or coming out of the pit, and so have prevented the products of combustion from going far inbye, there being plenty of air already in the pit to keep the men alive if the smoke could be kept from them. When a large body of air was going into a pit, it possessed a momentum that could not be stopped all at once; and, even if one of the shafts had been covered up, there would have been a depression at one shaft and an accumulative pressure at the other. At any rate, a condition of quiescence (more or less) at the pit-bottom would have been produced, and the draught kept from the fire. He was not prepared to say that it would at once stop the air from moving all through the workings, as it might go round in a circle through some doors, until finally it came to rest. But the great bulk of the smoke would be prevented from going from the fire into the workings of the mine, and that would have given the men a chance to live. They were told that 24 hours after the outbreak, despite the fumes, in the course of exploring some parts of the mine a cat, and also two horses, were found alive.* Surely, then, it stood to reason that if they had stopped the air in the way he suggested a better chance for life would have been given. It would no doubt have been trying an experiment in ventilation, but it was a question, under circumstances of that kind, whether such an experiment was rash.

He was quite prepared to find, when Mr. Redmayne came to give his explanation, that he (Mr. Blackett) had failed to consider everything, but he should certainly like to know wherein the failure lay.

Mr. Leach bore out what Mr. Blackett had said, and remarked that the same thing occurred with a fan at Seghill colliery. When it drew air from the surface, owing to the separation doors in the fan-drift being open, the indicated horse-power increased from 30 to 212, and if the air had been curtailed

* *Report on the Causes of and Circumstances attending an Underground Fire which occurred at Hamstead Colliery, on 4th March, 1908*, by R. A. S. Redmayne, 1908 [Cd. 4231], pages 12 and 13.

the strain would have been less. The only strain, and the greatest strain, that could be put on a fan, was by the engine that drove it, except at the moment of an explosion. He found that some people were considering the effect of having duplicate drifts, so that in a case like that at Hamstead they could force the air down the upcast shaft by opening one door and closing another in the fan-drift.

Mr. Blackett remarked that the whole point he wished to emphasize was that by attempting to pull the air back from the direction in which it was going, thinner air would be got, and thin air was easier to throw off than thick.

Mr. Edward Watson (Chester-le-Street) said that some 9 years ago he had, at South Pelaw colliery, an experience similar to that which occurred at Hamstead. They stopped the fan, and in about an hour's time went down the upcast shaft and got some twenty-four men out, there being only one elderly man lost, and he died of pneumonia some days after the fire. He happened to have the advice of Mr. Henry Armstrong almost at once, and the air-current was reversed in about an hour and a half after the fire occurred. They did nothing but stop the fan and open the upcast shaft. The fire itself reversed the ventilation, and when reading the account of the Hamstead fire he had wondered why this was not done.

Mr. William Heslop (Howden-le-Wear) said that a few years ago Binchester colliery heapstead and shaft-gearing took fire, and there were a certain number of men in the workings. As soon as Mr. Fishwick (the then manager of the colliery) arrived upon the scene, and observed the smoke going down the shaft, he stopped the fan and made the downcast the upcast shaft, and at once the rescue-party were enabled to go down the upcast (now the downcast shaft) and take what was the return airway as the intake. There was no one lost, but the whole of the heapstead was burned to the ground.

Mr. J. H. Nicholson (Blyth) remarked that the reversing of fans required some consideration, and this question might be further gone into by the Council of the Institute. Some time had elapsed since they had had any report on fans and ventilation generally, and perhaps the Council would take the question up.

The PRESIDENT (Mr. T. E. Forster) said that there were fans made to ventilate either way. He believed that in Nova Scotia at one time some of the fans were run one way in summer and reversed in winter on account of ice in the shaft, and he thought that Mr. Capell had built several fans of this description. This was a question which had been brought before the Royal Commission on Mines, and they had taken evidence on it. It seemed to him that great care should be exercised in reversing the ventilation, as it depended on what the returns contained.

Mr. T. C. FUTERS (Monkseaton) said that in the Coal-mines Regulation Act it was provided that there must be two outlets, that proper apparatus for raising and lowering should be kept on the works belonging to the mine, and that such apparatus (if not actually in use) should be constantly available for use. It seemed to him a question of maintenance of the plant. If a winding-engine had to be kept constantly available for use, it meant that it must not be possible for it to break down, or, if it did break down, there must be readily available a duplicate engine to take its place, not necessarily a duplicate large winding-engine, but a small jack-engine or other means to get the workmen out of the pit.

Mr. BLACKETT remarked that that was the point; to read the Act in that way would be not only contrary to the intention of the Act but an unreasonable way of reading it, and he thought it would fail in equity if not in strict interpretation. They all knew that the wording of both Act and Rules was far from what could be desired. The suggestion that a spare engine disposed of the difficulty failed, because two engines could break down as effectually as one. The probabilities became more remote, but the possibilities still remained.

The PRESIDENT asked whether Mr. Blackett considered that if the winding-engine on the upcast shaft had broken down the pit could be worked.

Mr. BLACKETT replied that the pit was not producing coal. The conclusion arrived at in the report was, "It will be observed that in 1(*a*) of Section 16 the expression 'for the time being at work' occurs. The mine was not at the time of the accident producing coal, but work was being performed in it. I take it,

therefore, that it was 'at work' within the meaning of the Act, and that a technical breach of the Coal Mines Regulation Act had been committed."* He (Mr. Blackett) would like to draw Mr. Redmayne's attention to the fact that the words "for the time being at work" referred to a seam and not to a mine, a very significant distinction.

Mr. Nicholson asked how many managers there were who would send more than the stipulated number of men down, or any man to do anything else than what was actually necessary, if the relief pit was out of order.

Mr. Blackett replied that it was not the pit—it was the engine.

Mr. Leach remarked that the engine and pit went together. If a winch were installed, they had all that was necessary.

The President said that Mr. Redmayne contended that there was a greater number of men down than was necessary for the work to be done. It had been asked how the pit was restored. He believed that, after all the efforts that had been made, the fire burnt itself out, and was not put out in any way. The "hanging-on" was in a stone drift, and after the air was reversed, and all the timber and coal-dust consumed, the fire went out. He considered that in the case of similar fires near shafts, it was of the utmost importance to have a good supply of water, and it was quite evident that if such had been the case at Hamstead the fire would probably have been extinguished; there was a pipe down the shaft, but there was no water in it. He thought that everybody should take care to have shaft pipes and a good supply of water, and in this way a good deal of the danger would be done away with. In Staffordshire they appeared to do some things which would be considered very extraordinary in the North of England. In the case in question, all the candles were kept in a big box at the bottom of the shaft, which was the cause of the disaster; this, no doubt, seemed to them in the North of England more like a custom which might have existed in the middle ages. With regard

* *Report on the Causes of and Circumstances attending an Underground Fire which occurred at Hamstead Colliery, on 4th March, 1908*, by R. A. S. Redmayne, 1908 [Cd. 4231], page 8.

to the point that Mr. Blackett raised as to the second shaft, when they came to have a fresh Coal-mines Regulation Act they might have a better definition of this than they had now. If they were to be summoned and fined on points of law which they did not understand, it would be better to have the matter put right.

DISCUSSION ON THE EXPLOSION AT WASHINGTON "GLEBE" COLLIERY.*

Mr. W. C. Blackett (Sacriston), in opening the discussion, said that he was sent for, and visited Washington Glebe colliery immediately after the explosion. The first point, however, that struck him in Mr. Atkinson's report, which was, as usual, full of detail and common sense, was that he (Mr. Blackett) was stated to have said at the inquest that "he thought an excess of dust might arrest explosion, but he gave no proof of this."† Of course, that was a thing of which no one could easily give any proof; but the possibility had been suggested to his mind by the explosion at Urpeth colliery, there being conditions in that explosion which he had never seen so marked elsewhere. There was more dust distilled at Urpeth than he had ever seen anywhere else; in fact, so profuse was the distillation that, when the air began to cool, the hot hydrocarbons were so greatly in excess of the available oxygen that it positively began to rain carbonaceous oily matter; and in very extensive areas the whole surface was covered with a soft oily blanket of sooty matter, about ¼ inch deep. They all knew that, in the case of fire-damp, with 7 per cent. of gas the mixture first became explosive, but that when it increased to 16·20 per cent. it ceased to be explosive. If, then, there was sufficient heat at any point to distil off 16·20 per cent. of gas, there might be such a rich mixture that it could not be fired, and, therefore, owing to the excess of dust over the oxygen available, the explosion might cease.

Some time ago he communicated a paper upon "The Combustion of Oxygen and Coal-dust in Mines"‡ to the members

* *Report to the Right Honourable the Secretary of State for the Home Department on the Circumstances attending an Explosion which occurred at Washington "Glebe" Colliery, in the County of Durham, on the 20th February, 1908*, by J. B. Atkinson, M.Sc., H.M. Inspector of Mines, 1908 [Cd. 4183].

† *Ibid.*, page 7.

‡ *Trans. Inst. M. E.*, 1894, vol. vii., page 54.

of the Institute, and, if any young man wanted a practical man's idea of what occurred in a colliery explosion, he believed that there was still some food for thought in that particular paper. In the paper he described how there was first an initiatory inflammation, which, expanding the gaseous contents of the gallery, produced an outrush of air. At the forefront that movement would be gentle, and would naturally follow the easiest and most open way: but, following on, would be the more violent current raising up the dust, producing what he had termed "pioneering phenomena," or, in other words, a condition favourable to the pursuing flame. On the plans attached to Mr. Atkinson's report the left-hand cross-cut coming in from the downcast shaft showed little violence, whereas other parts showed a great deal, and Mr. Atkinson drew attention to that fact, but he (Mr. Blackett) did not gather that he accounted for it. Mr. Atkinson said that—

"The left main winning place which had been the intake airway at the time of the explosion had escaped, beyond the fact that bricks and *debris* were blown into it where stentons connected it with the haulage road. The three ponies in a temporary stable in this road near the upcast shaft were not burned."*

And, continuing, stated that—

"This road . . . was the intake airway, and according to the usual experience in extensive explosions was the road along which the explosion might have been expected to extend with the greatest violence. It was the passage in the seam where the air would almost certainly contain the least proportion of fire-damp, but had the ordinary practice been followed of making it also the main haulage road it would have contained most coal dust; as it was only used as an intake airway and only acted as a subsidiary haulage road for the coal worked in driving it and then only beyond the last connection with the centre winning, it did not contain more coal dust than an ordinary road, and this dust had been much obscured by the shooting down of 16 inches of stone from the roof over its entire length. The sample D11, Appendix II., taken from the floor of this road at the point marked on the 4-chain plan it will be noted contains 62·8 per cent. of ash, the highest percentage in any of the specimens given in the table."

"There might very well have been a deposit of the fine upper coal dust from the screens on the surface and the tubs while being raised in the downcast shaft on this road, which was, however, absent probably due to these reasons."†

And then follow his reasons.

The explosion did not take this left-hand road, and Mr.

* *Report to the Right Honourable the Secretary of State for the Home Department on the Circumstances attending an Explosion which occurred at Washington "Glebe" Colliery, in the County of Durham, on the 20th February, 1908*, by J. B. Atkinson, M.Sc., H.M. Inspector of Mines, 1908 [Cd. 4183], page 13.

† *Ibid.*

Atkinson gives as his reasons the dust only. With every respect to Mr. Atkinson, he thought that there might be a further reason that it was not the road which the gentle current of pioneering air could most easily follow in order to raise up the dust for the explosion. Subsequently it was easy for the explosion to blow out a stopping, but as conditions were unprepared beyond, no violence took place. Undoubtedly the analysis of the dust shewed a large percentage of ash, but he questioned whether the analysis was correct, yielding as it did 62·8 per cent. of ash, 30·5 per cent. of volatile matter, and 6·7 per cent. of carbonaceous matter. He could scarcely believe that such an analysis could be obtained. There was as much volatile matter as was in coal, and certainly it would have exploded if it had got the chance. Mr. Atkinson also mentioned the interesting fact that there were no indications of force or flame observed at the face of any of the *culs-de-sac* or unholed places, except that in which the explosion began, and in one or two of limited length.* This, of course, was also due to the absence of the pioneering air-flow, and was a phenomenon that he had observed for many years, and he was glad to see that Mr. Atkinson was impressed by it.

Mr. Atkinson also mentioned his (Mr. Blackett's) remark about an overcharged shot.† He (Mr. Blackett) might have called it an overcharged shot, but did not intend that designation to be taken literally. The shot in all probability was an ordinary one, but it had had too little work to do, and, of course, that made it equivalent to an overcharged shot.

He (Mr. Blackett) had a very strong impression that if a simple screen of some sort or other had been hung in front of that shot at Washington, it would have cut off flame from the phenomena in front, and might have prevented the explosion. That was a view which he had suggested for experimental verification at the Altofts gallery; he was interested to find that the scientist in charge was inclined to agree with his supposition, and he looked forward to the result of the experiment. He was inclined to hope that such a simple screen might cut off the flame of the shot from any dust that was raised.

* *Report to the Right Honourable the Secretary of State for the Home Department on the Circumstances attending an Explosion which occurred at Washington "Glebe" Colliery, in the County of Durham, on the 20th February, 1908*, by J. B. Atkinson, M.Sc., H.M. Inspector of Mines, 1908 [Cd. 4183], page 14.

† *Ibid.*, page 15.

Mr. Atkinson cast a doubt upon the doctor's opinion that some of the men died from violence and not from carbon monoxide.* He (Mr. Blackett) was perfectly certain that they died of carbon monoxide; they had not time to die from violence, and all the symptoms of carbon-monoxide poisoning were there.

Prof. Henry Louis (Newcastle-upon-Tyne) said that he thought he might be able to throw some light on the obscure point of that abnormal sample of coal-dust. He had himself gone down the pit with Mr. Atkinson and taken all the samples. They were analysed at the metallurgical laboratory at Armstrong College, and that particular sample attracted his attention, and consequently some further analyses of it were made. It was not really coal-dust, but about 60 per cent. was shale and sandstone, the former of which contained water of hydration. The inorganic matter contained (from ultimate analysis by Mr. Blair) carbon, 72·4 per cent.; hydrogen, 5·11 per cent.; oxygen, nitrogen, and sulphur, 22·01 per cent.; and the volatile matter was extremely rich in carbon. He had pointed this out to Mr. Atkinson, and he had hoped that a foot-note would have been made about it. He had not the slightest doubt as to the accuracy of the analysis, which had been repeated several times. The material was mainly stone, but some particles of carbonaceous matter could be seen in it by examining it with a magnifying glass. Personally, he had not the slightest doubt that the explanation given by Mr. Atkinson was the correct one, and that the explosion did not travel down that particular airway because there was no food for it; although it was the intake, there was no explosion there, because it had not been used as a haulage road, and there was practically no coal-dust upon it. There were several samples of dust taken, and he had not the slightest doubt, speaking from his examination of the ground as well as of the samples, that that particular dust in that intake was practically all inorganic dust.

Mr. Blackett thought it extraordinary to include water in volatile matter in such an analysis.

The President (Mr. T. E. Forster) remarked that it was not called dust in the table.

* *Report to the Right Honourable the Secretary of State for the Home Department on the Circumstances attending an Explosion which occurred at Washington "Glebe" Colliery, in the County of Durham, on the 20th February, 1908*, by J. B. Atkinson, M.Sc., H M. Inspector of Mines, 1908 [Cd. 4183], page 16.

Prof. Louis said that all the samples were taken in exactly the same way, by taking up the whole of the dust they could scoop up over a definite though small area. A noticeable point to him was that there was so very little coking action to be seen in the pit. At first they had difficulty in finding any, but they did ultimately get evidence of it, and he was at a loss to account for this absence. He would like to see Mr. Blackett's suggestion of a screen experimented with. Whether it would have been valuable in the Washington explosion he could not say, because he had no doubt that that explosion was a gas explosion in its inception. When he went down the pit they had difficulty in getting into the place where the shot was fired. There was a good deal of gas showing in the face where the shot was fired, and also for some distance back, and his own definite conclusion was that the explosion was, in its inception, a gas explosion.

He was not quite sure whether Mr. Blackett's point about the possibility of excessive dust quenching an explosion, like an excess of coal-gas, was quite sound. He could see theoretical objections to it. It was a very easy matter to experiment on, and so far as their experiments had gone at Armstrong College, he did not think that they had ever found that an excess of dust had prevented an explosion from taking place.

Mr. Blackett asked what Prof. Louis meant by a strange absence of dust.

Prof. Louis replied that he was referring to "coked dust" on props and other parts.

Mr. Blackett said that he did not think there was anything very strange about that. For instance, at Urpeth there was an explosion of the greatest proportion of dust he had ever seen. The intumesced dust was sticky, and so soon as the current was reversed, following up the vacuum naturally taking place when the hot air began to cool down again, this hot sticky dust all collected in the most extraordinary and plentiful way on the sides of the props. The Washington explosion, on the other hand, was different. There was not so much dust as at Urpeth; at any rate, there was not so very much dust in the air, and in all probability the combustion was a little more complete, and the resulting dust, while being less plentiful, was more completely coked and not so sticky, and so would not be seen in such quantities on the props or elsewhere.

Mr. J. P. Kirkup (Burnhope) said that he would like to express his appreciation of the excellent report drawn up by Mr. Atkinson. He would have wished that the discussion had taken rather different lines, and followed the object for which the report was written, which he took to be the prevention of a repetition of such a disaster. Mr. Atkinson in his summary submitted his conclusions, the last three paragraphs* of which he (Mr. Kirkup) regarded as the most important items to be remembered. These were —

"(1) The necessity of shot firers understanding fully all the conditions of danger."

"(2) The provision of some more satisfactory means of testing for fire-damp."

"(3) The removal of any doubt on the subject of watering, removing, or otherwise rendering harmless, coal dust on the floor of working places before shots are fired."

He (Mr. Kirkup) thought that, as mining engineers and colliery managers, there would be few among them who did not acknowledge the danger arising from coal-dust; but he was afraid that as much could not be said of the human factor that they had to control. He very much doubted whether shot-firers and firemen were convinced in their own minds of the actual danger existing in coal-dust, and he thought that it would be well if they were to turn their attention to enlarging their education, not so much from rule, because they had too much rule, and too little common sense attending it, but to partly remove from their minds the idea of the danger arising solely from the presence of gas, and to direct it more to the question of the danger of the presence of coal-dust in even very small quantities.

He saw an extraordinary experiment carried out a few weeks previously at Altofts colliery, in which coal-dust was exploded without any gas whatever; and what surprised him was the extremely small quantity of coal-dust—averaging ½ ounce to the square foot over the experimental gallery, and it was not distributed evenly. Mr. Garforth was very dubious about the experiment being a successful one. He (Mr. Kirkup) examined the gallery and saw the dust scattered, there being 350 feet of the gallery over which the dust was distributed. A cannon, simulating a blown-out shot, was put 90 feet within the dust area, and a

* *Report to the Right Honourable the Secretary of State for the Home Department on the Circumstances attending an Explosion which occurred at Washington "Glebe" Colliery, in the County of Durham, on the 20th February, 1908*, by J. B. Atkinson, M.Sc., H.M. Inspector of Mines, 1908 [Cd. 4183], page 20.

most terrific explosion occurred; in fact, it gave one a very forcible idea of what the effects are in a colliery. The box of a coal-tub, placed at the mouth of the gallery on the ground, without any tram-plates, was blown into the air for nearly 450 feet. The column of smoke and flame shot up an equal distance, and one peculiarity about it, which was particularly remarked, was that following the explosion a big tongue of flame rolled out of the mouth of the gallery; but this flame when it came into the air—being preceded by a huge column of black smoke—seemed to greatly extend as if by the access of an additional supply of fresh air. He thought that if the Institute could forcibly bring before all shot-firers the danger attending coal-dust, a good deal might be done to avoid these disasters.

The PRESIDENT, in concluding the discussion, remarked that he thought that there was no doubt a good deal might be done by calling the attention of shot-firers to dangerous customs. He was sometimes struck when reading the accounts of single accidents that the shot-firers did not seem to understand these dangers fully. Some collieries had their own particular rules for shot-firers, apart from the rules in the Act of Parliament, and it was a point which required the attention of all colliery managers.

Mr. HUGH CLARKSON ANNETT's paper on "The Working of the Inclined Seams in the St. Étienne Coal-field, at the Montrambert and La Béraudière Collieries," was taken as read, as follows:—

THE WORKING OF THE INCLINED SEAMS IN THE ST. ÉTIENNE COAL-FIELD, AT THE MONTRAMBERT AND LA BÉRAUDIÈRE COLLIERIES.

By HUGH CLARKSON ANNETT.

I.—Introduction.

The seams in the St. Étienne coal-field are, as a general rule, most irregular, not only as regards thickness, but in inclination, as well as quality of coal: and, perhaps, in no area of the basin is this irregularity so pronounced as it is in the Montrambert and La Béraudière concession.

As many excellent papers have been written on the causes of these irregularities, and the formation of the basin, the writer does not propose to enter upon a geological discussion; but, as an introduction to the actual working of the seams, to give in a few words some reasons which are generally received as accounting for these irregularities.

(1) "The drift theory" is that which is most generally accepted for the formation of the coal in this basin, the reasons for the support of this theory being:—

(*a*) There are no defined underclays to the seams, but stone of a clayey nature may be found in the coal.

(*b*) The large rocks, or "rock-faults," found in the seams must have been deposited during the period of formation of the coal; and, as it is found that the seam thickens out when this rock is encountered, it is presumed that the drifting material which went to form the coal heaped itself around these rocks.

(*c*) Where stone in the seam is met with, it does not occur in the form of a regular band, but in blocks here and there, evidently carried down with the vegetation.

Perhaps the fact that the cleat of the coal is scarcely noticeable may be accounted for by the coal-forming material having been drifted and deposited in masses, instead of being gradually formed of layer after layer of vegetation, as occurs in the conditions of coal formation as explained by the *in situ* theory. At

the same time, disturbance of the strata might account for this feature in the coal, and it is a fact that, where the coal appears to have been less disturbed, the cleat is somewhat more marked than usual.

(2) Another reason for the cause of these irregularities is that the basin has undergone great distortion, due to disturbances having taken place at a time after the formation of coal, and when other strata had been formed above, as the measures above follow the same main lines as the measures below the seam. In this way, great pressures have been brought to bear on the strata, materially changing existing conditions.

The basin is bounded by mountain ranges, and stretches from the River Loire, on the west, to the River Rhône, on the east—a distance of 30 miles (48 kilometres)—and, although it is not exploited for all of this distance, it contains something like 30 easily workable seams. To the north and south of the basin are very large mountain ranges, and it is towards these latter mountains (Mountains of Pilat) that the strata has been most severely disturbed, and thrown up into a more or less vertical position. As the Montrambert and La Béraudière concession lies to the south of the basin—the most disturbed part—this accounts for the seams of the concession being more irregular than those of most of the other concessions. Fig. 1 (Plate XVI.) gives a sketch of the boundaries of the basin, showing the Montrambert and La Béraudière concession, and Fig. 2 is a section along AB of Fig. 1 to show the lie of the beds. Fig. 3 gives a section of the seams at La Béraudière. The irregularities in thickness, inclination, and quality of coal in the seams, may have been caused as follows:—

(*a*) *Varying Thickness of Seams.*—The coal-forming material, having been deposited on an uneven floor, would account for the thickenings and thinnings of the seams; and stressing of the strata by disturbances, to such an extent as to cause "swells" to occur, and even a thinning out of the seam.

The suggestion that contemporaneous erosion, due to streams coursing through the vegetation, may be responsible for thinnings, does not appear to be held in favour here.

(*b*) *Varying Inclination of Seams.*—As will be shown later, the inclinations of the seams vary considerably, and, in some

cases, great variations take place quite suddenly within a small area, even though there be no fault near to have disturbed the strata. One of these local variations is shown in Fig. 9 (Plate XVI.) and, as they are often accompanied by a thickening or thinning out of the seam, it may be presumed to be due also to the deposition of material on undulating ground. The variations which occur in the inclination of a seam throughout the concession are accounted for by the folding of strata which has taken place, as well as by some very large faults which traverse the entire basin.

(*c*) *Varying Quality of Coal.*—This is most probably due to the conditions under which the material was laid down, as force of currents, etc., and a certain mixture of sand and other materials brought in with the vegetation.

These, briefly described, are the conditions to which the seams of coal have been subject; and, owing to the greatly varying conditions at Montrambert and La Béraudière, it is necessary to apply various methods of working in the winning of the coal in this district.

II.—Winning-places.

Although offering no difficulties in their working, the winning-places are somewhat costly, as many of them have to be driven in stone, sometimes for long distances, due to the fact that the shaft is sunk to the side of all the seams, so that, to reach them, a gallery must be driven from it, through the intervening stone to the seam or seams to be worked.

The shaft having been sunk past the "stage" to be worked, two cross-cuts or stone drifts are put away from it to meet the seams, one cross-cut being made from a point in the shaft a certain distance above the other one, according to the height of the stage, there being a cross-cut at the top and another at the bottom of this stage. These stone drifts are taken away at a very slight rise, just sufficient to assist the full tubs coming outbye without unduly increasing the labour of taking the empty ones inbye, and also to enable water to run towards the shaft. As the drifts eventually serve as rolleyways, they are made a good width and height.

If the stone is good, these cross-cuts are timbered carefully, but if it is bad, a brick arching is made, this being very much

cheaper than continually renewing the timber which is broken, due to the great pressures brought to bear on it. The distance one cross-cut is above the other depends on the conditions prevailing, and varies from 108 to 216 feet (33 to 66 metres). Of course, if the coal has been worked in the stage above, the top cross-cut of the new stage will already be made, as it will have been the bottom one of the old stage.

When the seam to be worked has been reached, the winning-places or main levels are driven along the seam, and generally to either side of the cross-cut; the distance they are driven depending upon the number of panels to be worked.

These levels are driven in the coal, and are therefore cheaper than the stone drifts or cross-cuts; but, as they are winning-places, a bigger price is paid than when getting the coal at a face. As there is only one place driven, it must be ventilated by pipes, and very often a small Mortier fan, driven by compressed air and connected to the pipes, is utilized for this purpose. Great attention must be paid to the timbering of these levels; and if the seam is not highly inclined, a canch at the wall-side will have to be taken up.

Finally, the top level of the stage will have to be put in communication with the upcast shaft, which will necessitate a cross-cut being driven in stone, unless a holing to some main return can be obtained by continuing the level.

When the necessary cross-cuts and levels of a stage have been driven, the main levels must be connected by driving one or more inclined planes in the seam, the number varying according to the method of working to be employed. The making of these inclined planes is very important, and on their inclination, etc., depends the successful working of the stage.

There are two different kinds of inclined plane in use. One —the ordinary method in the North of England—is the plane on which there are two sets of rails, and the full tub descending pulls up the empty tub; the other method is the one in which the tub rests on a platform, provided with wheels, the platform being level, and a counterpoise is employed. This counterpoise is a mean between the weight of the full tub and platform and the empty tub and platform, so that the full tub descending pulls up the counterpoise, which runs below the platform, and this in turn descending pulls up the empty tub and platform after the tubs have been changed at the bottom.

In both of these methods, the plane is driven in coal, in as straight a line as possible, sometimes in an ascending direction, and sometimes in a descending direction, whichever appears to be most convenient. There is no certainty as to which is the better direction in which to work, since, when ascending, the coals fall to the bottom by gravity, but the men are not so free to move about; whilst, if the coal is tender, the face when driven in an ascending direction has to be stayed to prevent heavy falls. Generally speaking, if the plane is not too steep, it is easier to ascend, and *vice versâ*, but this is not always the case. Since these planes follow the seam, they are not by any means straight, and are therefore at first driven narrow about 59 inches (1½ metres) and afterwards widened out by side-canches —taken in stone if need be—from either one side or the other, and so by widening out, it is possible at the same time to straighten the plane. Of course, in thick seams the plane can be driven its full width in one operation. If the seam is very steeply inclined, the plane is made, not in the line of true dip of the seam—as that would be much too steep an angle at which to work—but along a line making an angle with it (the line of true dip), the size of the angle varying, of course, with the inclination of the seam. The ordinary method of plane—where the full tub pulls up the empty one—can deal with more coal than the counterpoise system. In the Grande Couche, where both systems are employed, the former deals with 500 to 600 tubs (9 hundredweight) per day, whilst the latter only deals with 200 tubs; so that, where there will be a large output from a stage, the ordinary method must be employed. But this method cannot be employed for working intermediate levels between two main levels, unless each level has a separate incline. This is sometimes done in places in the Grande Couche where there is to be a very large production from the stage, each "small-stage" working having a separate incline. The counterpoise method is very convenient for working intermediate levels, that is, levels at intervals between the top and bottom main levels, and this plane can also be maintained, where the roof is bad, much better than the plane in the ordinary method, which, being necessarily wider, requires much timbering. Again, it is often convenient to have the plane running as near the direction of true dip as possible, and therefore, if the seam is not too steep, that is, more than 50 degrees, the counterpoise plane can be made in the true

dip. Each method is, therefore, indispensable. The plane in the ordinary method is not made at a steeper angle than 30 degrees, whilst the counterpoise plane must have a greater angle than 30 degrees, otherwise the speed of running is too slow. The usual inclination of this plane is from 40 to 45 degrees. The area between two cross-cuts is termed a "stage," and the manner in which a stage of a seam is to be worked depends entirely upon the seam itself, and upon the physical properties of the coal. The bottom level of a stage is the intake, whilst the top level forms the return. The cost of driving the planes varies, being £2 11s. 6d. to £2 15s. 6d. (65 to 70 francs) per metre (40 inches) with the ton price of any coal got in the operation for thin seams, and 17s. 6d. (22 francs) per metre with the ton price of coal, for the thickest seams. The inclined plane having been made, a connection between the two main levels is obtained, and the preliminary operations of a stage being now finished, the working of the coal in this stage is begun.

In every case, no matter what method of working may be adopted, the goaf must be completely stowed up in a systematic manner, owing to the thickness and inclinations of the seam. An Act compels this to be done. For this purpose there are stone-quarries at bank, and a contractor undertakes to quarry the stone and put it down the pit for about 3d. (28 centimes) per tub of 14 cubic feet (400 litres) capacity. The cost per ton of coal, for stowing, amounts to 9½d., of which the quarrying costs nearly 3d. and the underground labour about 7d. The haulage cost of this stone—which is generally a sandstone or a hardish shale—is very little, as gravity does most of this work, the stone being put down to the top level of a stage and going down to the faces by the inclined planes.

Coal-seams.—The seams worked are as follows, in their geological order:—

Name.	Average Thickness. Ft. Ins.	Average Thickness. Metres.	Inclination. Degrees.
1. Chauvetière No. 1	8 2	2·5	75 to 90
2. ,, ,, 2	4 7	1·4	75 to 90
3. Mouillée ,, 1	4 7	1·4	75 to 90
4. ,, ,, 2	Not being worked at present.		
5. Couche des Littes	4 11	1·5	About 45
6. Grande Couche	9 10 to 82 0	3 to 25	20 to 90
7. Brûlante No. 1	4 0	1·2	10 to 80
8. ,, ,, 2	6½ to 13 feet	2 to 4	15 to 80
9. ,, ,, 3	9 ft. 10 ins. to 19 ft. 8 ins.	3 to 6	15 to 80

The above table demonstrates the variable nature of the seams. Some seams may be dipping at 80 degrees or be vertical in one district, and in another district the same seams may dip at 40 or even 25 degrees. The quality of coal varies greatly, it being very soft in places and very hard in others, good here and bad there, clean in one part, and stony in another.

Generally speaking, the Chauvetière, Mouillée, and the Couche des Littes are fairly regular as regards inclination and thickness, although the coal itself varies in hardness. The Grande Couche and the Brûlante are most irregular. The Brûlante No. 1, whilst not a thick seam, yields a very poor quality of coal, and is so irregular in inclination that it is only convenient to work it when there is a large demand for coal.

The coal of the Brûlante Nos. 2 and 3 is of a most inflammable nature, and hence great care must be taken to get all the coal out to avoid crushing, and to shut off completely all air from the coal where a main cross-cut intersects the seam. This is done by putting in a walling of clay. The workings are always at a very high temperature, which makes it exceedingly troublesome for the men employed.

Naturally all these irregularities produce great difficulties in working, and it is sometimes found necessary to change from one system to another. This is especially the case with greatly varying inclinations in the thinner seams, where the methods adopted depend upon the inclination only, and not upon the thickness and the quality of coal.

III.—Methods of Working.

These may be classed as follows:—(1) The overhand stope, or vertically stepped-face method (*rabattage*); (2) advancing-faces method (*tailles chassantes*); (3) single horizontal-slice method (*tranche horizontale*); and (4) multiple horizontal-slice method (*tranches horizontales*). The first three differ from each other to a considerable extent, but the last method is simply a combination of the other three.

(1) *Overhand Stope or Vertically Stepped-face Method.*—This method is employed in thin seams having a very high inclination to the horizontal. In fact, it may be said that the nearer to the vertical a seam is, the more easily this method may

be employed, at any rate, with regard to the upkeep of intermediate levels. It is therefore specially applicable to the Chauvetière and Mouillée seams, which are thin and highly inclined, and at times is also applicable to the very irregular Brûlante No. 1, whilst even the Couche des Littes and Brûlante No. 2, may be worked by this method, although this is not general. It is therefore with special regard to the working of the two Chauvetière seams that the writer proposes to describe the method in question.

To describe it roughly, it consists of taking away the coal between the roof and the wall at one operation by a series of levels one above the other—the bottom level always being slightly in advance of the one above it—and stowing the space excavated with stone, maintaining, at the same time, suitable levels to carry the coal from the faces to the inclined plane. A stage is formed by two main levels being made, one at the top and the other at the bottom. The top level is, of course, already made, being the bottom main level of the stage above; but it may have to be put into direct communication with an upcast shaft, as it is now the return airway for this stage. The stage is now divided into a number of panels 656 feet (200 metres) long, the boundaries of these panels being imaginary lines which are not vertical, but inclined, and generally parallel with the line of direction of the inclined plane, which is made in the middle of the panel. The seam being very steep—it may be vertical—the plane is made in a line, making an angle with the direction of true dip. This plane is, therefore, made on the counterpoise system, and has generally an angle of inclination to the horizontal of 42 degrees. The plane will work the coal for 328 feet (100 metres) on each side of it, and between the two main levels, which are at a vertical distance of 164 feet (50 metres) apart, the present working stage being the 1,112 to 1,276 feet (339 to 389 metres) stage. In this case, the length of the plane is considerable, and, if it so happened that it became necessary to repair it at the top, work would be suspended at the bottom because of the danger incurred by the workmen from falling stones. To enable repairing to be done at the top, whilst work proceeds at the bottom, what is termed "the bayonette incline" is made; that is, the incline is taken away level when it has gone about

half its distance, and this level is continued for about 16 to 20 feet (5 to 6 metres), when the incline is again set away. When driven in the true dip, the plane is at right-angles to this level place, although when it is driven in a direction not in the true dip, it is, of course, not at right-angles. For this incline, therefore, two rope-drums are necessary, one being at the top of each inclined plane so formed, and tubs must be changed; but it is found to pay better, and also does away with the necessity of a counterbalance-rope. The actual winning of the coal from the panel is now begun. Each panel is divided into "small stages" of 23 feet (7 metres) vertical height, and each small stage is composed of three faces, or levels, one above the other, of 7½ feet (2·3 metres) vertical height. A face is always in advance of the one above it, and the bottom face, or level, of a small stage is invariably maintained to allow the coal of that small stage to be taken to the plane; the other two above it are stowed up as they advance, the stowing being kept at a distance of about 16 feet (5 metres) from the face, which is about 40 inches (1 metre) more than the amount by which one face is in advance of the one above it. In this way a communication is left between the faces, for air to travel, and also to enable the coal from the two upper faces of a small stage to be put down onto their level, and to go thence to the plane. The coal is worked away from the inclined plane, and on each side of it to the boundary of the panel. The bottom of the panel is first attacked, the bottom main level, or intake, being the first level of the first small stage. A face is set away above this level, and when it has gone a distance of 13 feet (4 metres) the third face is set away, and this having been driven for a distance of 13 feet (4 metres) the fourth face, or the first face of the second small stage, is started, and so on.

The bottom small stage is sometimes started before the inclined plane is quite ready, that is, when it is being straightened by taking stone canches, as explained previously. This is possible, as the plane is not required for the first small stage, except as an airway, and is a great advantage, as then the stone got from the plane can be used as stowing, without having to remove it to some other part of the mine.

No. 1 level, which is the main level and intake, is, of course, maintained, Nos. 2 and 3 are stowed as they advance,

whilst No. 4, being the first level of the second small stage, is maintained, and so on. There are generally two or three small stages (six or nine faces) being worked at one time, with one hewer for each face, and, when the end of the panel is reached, a new small stage or *rabattage*, is started. The bottom main level is never stowed up, but when the top face of a small stage has reached the boundary of a panel, the bottom level of that small stage is completely stowed, excepting for a small airway, which is maintained between the coal-face and the stowing, this serving to conduct the air to the faces of the small stages working above. The air, which is always ascending, comes along the bottom main level, and, ascending by the working-faces, travels along the highest working level of the panel, on to the inclined plane, whence it ascends to the top main level, or return, and so passes to the upcast shaft. The return level not only serves as a return airway, but is also used to bring timber and stowing material to the top of the inclined plane, from which point it is put down to the faces. The bottom main level is a coal rolleyway and intake. The working-off of the last, that is the topmost, face in a panel is rendered difficult by reason of holing into the main level above, and so disturbing the timber of that level, which, of course, is supporting a great weight of stowing. This difficulty may be overcome in two ways, namely:—

(1) When the main level is driven, it is made 4¼ feet (1·3 metres) higher than usual. Timber is now laid across the floor of the level, and stowing put on the top of it to a height of 4¼ feet (1·3 metres), thus reducing the height of the level to its normal size; and when, consequently, the last level of the panel below is worked, there remains a thickness of stowing, supported on timber, between the top of the level and the bottom of the main level.

(2) It is generally found necessary, if the above method is not adopted, to leave a thin roof of coal 9·8 to 11·8 inches (25 to 30 centimetres) thick between the two levels. The hewer at the face makes a platform to stand upon, by a plank or two put across from the roof to the footwall, or what is really the floor of the seam. This is necessary, owing to the holing down on to the level below, the stowing of this level not being

right up to his coal-face. The coal from an upper face of a small stage can be thrown directly into a tub, standing on the bottom level of this stage. But if the tub is not there, instead of allowing the coal to fall down on to the way, and so hinder the passage of a tub to the face of the bottom level, a platform of planks is erected above this level, the planks resting on horizontal cross-props, fitted between the two vertical supporting props of the level, and of such a height as to allow the passage of a tub beneath. By running a tub below the platform, and removing the planks, the coal falls into the tub.

In certain places, the Chauvetière No. 1 seam becomes less inclined locally, the inclination being 45 to 50 degrees. This makes the horizontal width of the seam much greater than the real thickness, and consequently the level is wider. It is therefore found necessary to build a packwall along the footwall, and keep it in advance of the ordinary stowing: in fact, to keep it close up to the face. This means an additional distance for casting the stowing, and it is therefore found to be better to stow every other face only, thus making two faces per small stage. In this way, the distance to cast the stowing to the face is the same as the distance of casting in the usual method.

Fig. 4 (Plate XVI.) shows a section of one small stage and the working-level of the next small stage above it, whilst Fig. 5 (Plate XVI.) shows the working of a panel. Here, the first four small stages are finished and completely stowed, excepting, of course, the bottom main level and the inclined airway at the panel end. Only the working at one side of the inclined plane has been shown, the other side being exactly similar. By this method each panel is worked off in an upward direction, although the seam itself is worked downwards: that is, when the panels between two main levels are worked off, a level is made below the bottom one, which now becomes the top main level, and the panels, so formed, are worked.

Naturally, one of the most important things, if not the most important, is the timbering. The timbering of the intake level will eventually support the stowing of the whole panel, where the seam is vertical—at any rate until it has settled down. Whilst, owing to the pressure of the roof and footwall, and the occasional tenderness of the coal and consequent pres-

sure of the seam, the timber must not only be substantial, but very carefully set. Furthermore, owing to the stowing above the working levels, it is necessary for the timber to be closely set, to prevent not only breakage of timber due to the weight of stowing, but also the stowing from falling between the timber.

Fig. 6 (Plate XVI.) gives an illustration of the mode of timbering adopted in this method, the numbers on the various timbers denoting the order of putting them in. The bottom level is timbered by two props and a cross-balk. The props rest on long props, running parallel with the direction of the level. One of the upright props is placed against the roof of the seam, whilst the other may be against the wall, or at a distance from it, according as the seam is thin or thick—the width between the props being about 4 feet (1·2 metres). If this prop is not against the wall, a packwall of stowage is built between it and the wall. To have this pack is an advantage, especially in the main intake level, as when this is first driven, the timber on the wallside becomes very much broken, owing to the heaving of the coal below. The two upright props are notched into the balk, which is also notched into the footwall. The two props are further supported by placing a cross-piece between them at a point at slightly more than half their height, so as to allow the passage of the tubs below it. This is the cross-piece on which the platform of planks, to receive the coal from the faces above, rests. Small pieces of deal can be placed across the balks, to prevent the smaller pieces of coal or stone from falling. So much for the timbering of the first level.

The next face, as it advances on top of this timber, is timbered in somewhat the same manner. It is supported also by a balk and two props, one prop being against the roof and the other against the footwall, both resting on the balk of the first level. A cross-piece is placed between them at their bottom ends, thus resting also on the balk of the level below. An upright prop is then placed in the centre, between this cross-piece and the top balk, giving additional support to it. This is sufficient to overcome the pressure of the roof and wall and to maintain the coal above. A platform for the stowing is now made, by laying longitudinal props, about 13 feet

(4 metres long), against the side-props and resting on the cross-pieces. Other props about 20 inches (50 centimetres) apart are laid across these, and on the top of these latter props, and at right-angles to them, are laid other props touching each other. On the top of these latter, the stowing is put. No. 3 level is then timbered in the same way, the upright props always coming directly over those in the level below. Fig. 7 (Plate XVI.) shows a method of timbering when the seam is less inclined and side packs are built. One hewer will produce 16 to 18 tubs, equal to 7 tons per day, at a price of 4d. (35 centimes) per tub, making his daily wage 4s. to 5s. (5½ to 6 francs).

(2) *Advancing-faces Method.*—Approximating in a way to the advancing longwall method in the North of England, this method is adapted to the working of thin seams, of 20 to 80 inches (½ to 2 metres), which are not very steeply inclined, being at 25 to 50 degrees, and it is therefore the method by which the Couche des Littes is almost invariably worked. Where the inclination of the Brûlante No. 1 allows, it is worked by this method, as is also the Brûlante No. 2 when it becomes thin at Montrambert, and so, too, the small seam which occurs in the roof of that seam. The working of the Couche des Littes furnishes perhaps the best example of this method of working.

There is no definite length of a panel in this case, the coal being won out on each side of the inclined plane, as far as it is found convenient to go. This inclined plane is of the counter-poise type, and is usually driven to the full dip, in order to obtain the necessary gradient (generally 40 to 45 degrees). The two main levels, being connected by the plane, which is nearly always of the bayonette type, the winning-out of all the coal in the panel is begun on each side of the plane, by a series of stepped inclined faces, going away from the plane and in a direction at right-angles to it. In this way it represents a longwall working, going at right-angles to the dip, and the whole height of the panel is taken away at the same time. The roof of the seam is, unlike the overhand stope, the roof of the working-place. The length of the faces varies, of course, according to the inclination of the seam: but for inclinations of 40 to 50 degrees (which are most general) the length of each

face is 33 to 40 feet (10 to 12 metres) giving a vertical height of face equal to 23 feet (7 metres). This vertical height is always kept at 23 feet (7 metres) and one face, as in the overhand-stope method, is always in advance of the one above it by about 16 feet (5 metres). Each place is carefully stowed back-bye, the stowing being kept about 13 feet (4 metres) back from the face. In this stowing, levels are maintained at the bottom of each face, to take the coal from that face to the plane. In this way, the coal won from a face falls by gravity onto the level, where it is put into a tub by a filler. In beginning the working of the panel, the bottom face is first started, and, when it has advanced a certain distance, the one above is begun, and so on, a face always being set away when the one below has advanced about 16 to 20 feet (5 to 6 metres). As the floor of the level in this case is the floor or footwall of the seam, a canch has generally to be taken up in the stone at one side of the level, to form a level way for the passage of the tubs. This canch measures seldom more than 20 inches ($\frac{1}{2}$ metre) at its thickest point, and tapers away to nothing. The stone got out is used for stowing, so that there is little, if any, extra cost for taking up these canches. The bottom main level (the intake) is the only winning place driven, as the top level was formed before, being the bottom level of the panel above, whilst the intermediate levels are formed, of course, as the faces advance. The air goes along the main level and ascends by the working-faces, and so goes to the return level at the top. Fig. 8 (Plate XVI.) shows a panel being worked by this method between the 1,112 and 1,276 feet (339 and 389 metres) levels, the arrows denoting the direction of the air-current. In this method, as in the preceding one, it will be seen that the vertical height between two maintained levels is 23 feet (7 metres). This is most convenient, because it is sometimes found necessary to change from the one method to the other, owing to a great change in the inclination of the seam. This is so in the case of the working of the Brûlante No. 1. This seam is 4 feet (1·2 metres) thick, with an inclination which is most variable, being vertical in the southern districts, 10 to 80 degrees in the central district, and 30 degrees in the northern. It is in the central district where the most trouble of working it is experienced, owing to the great

variation in dip. Fig. 9 (Plate XVI.) shows the varying dip of the seam at two places in the same panel in this district. Where the inclination is less than 50 degrees, it is worked by the advancing-faces method; but when the inclination is greater, it becomes necessary to change to the overhand-stope method. The passing from one method to the other is then a matter of no great difficulty, if the levels have been kept at a vertical distance of 23 feet (7 metres) apart, the space between them now becoming a small stage, and the face of each existing level becomes the bottom face of a small stage, which is worked off by three faces. Fig. 10 (Plate XVI.) gives an illustration of the passing from one method to the other.

The timbering is quite ordinary, but requires to be carefully done, owing to the large pressure on the roof. It consists of small balks, or planks, put across the roof at right-angles to the direction of the face, and about 20 to 40 inches ($\frac{1}{2}$ to 1 metre) apart, the distance apart varying, of course, as the stone is good or bad. These planks are supported at their ends by longitudinal props, about 10 to 13 feet (3 to 4 metres) in length, set at right-angles to them, these long bars being, in turn, supported by three props—one at each end and the other in the middle—which are set into a hole in the floor. These latter props are set not quite at right-angles to the dip of the seam, but slightly more inclined to the vertical, so that a downward thrust, due to the inclination of the strata, tends to tighten rather than slacken them. Small pieces of deal are generally inserted between the planks, to prevent any loose stuff from falling. Fig. 11 (Plate XVI.) is an illustration of the mode of timbering. There are generally three to four hewers per face, each hewer producing 15 tubs of over 8 hundredweights (410 kilogrammes) per day of 8 hours, which is equal to $6\frac{1}{2}$ tons at 4d. (35 centimes) per tub or 4s. 2d. to 5s. ($5\frac{1}{4}$ to 6 francs) per day.

(3) *Single Horizontal-slice Method.*—This is, perhaps, the most important method, as it furnishes a very efficient means of working the extremely thick seams; and, as it can be employed in thick seams of any inclination, it is therefore specially applicable to the Grande Couche, and, in consequence, has been adopted as the only method of working this seam, which, as has already been described, is exceedingly variable in every particu-

lar. It dips eastwards at Ferrouillat (Nord), at 30 to 50 degrees, is highly inclined, and in places vertical in the central district, and dips at 70 to 80 degrees westwards in the southern district. In parts, the seam is only 10 feet (3 metres) thick, whilst at other parts it increases to 82 feet (25 metres) in thickness. It is often 46 feet (14 metres) thick, and an average thickness is about 40 feet (12 metres). In the central district the coal is generally hard and bad, whilst in the southern district, it is very friable, but good. At times it is tender and then suddenly becomes hard, sometimes clean and at other times very stony, bands of stone over 16 feet (5 metres) thick being often found. As a general rule, the quality of coal is poor and stony at abnormal thickenings, such as 65 to 82 feet (20 to 25 metres).

Although differing in details according to the variations in the thickness, inclination, and quality of the coal, the general method is always the same. As has been shown, the thickness of the seam is sometimes 82 feet (25 metres); but, when this thickness appears, and the seam is not highly inclined, the horizontal distance from roof to wall is sometimes 131 feet (40 metres). The stage to be worked is divided into small stages of about 36 to 40 feet (11 to 12 metres) in vertical height, and these small stages are worked off in descending order, by a series of slices $6\frac{1}{2}$ to $7\frac{1}{2}$ feet (2 to 2·3 metres) high, which latter are worked off in ascending order. Or, in other words, the first part of a stage to be begun is the bottom slice of the topmost small stage. There are four to five slices in one small stage and only one slice is worked off at a time, although the one above it may be in preparation. Two inclined planes, at least, are necessary, one for coal and the intake air, the other for stowing and the return air. The latter is made at the farther end of the panel, whilst the former, although it may be towards the middle, is almost invariably at the beginning. The intake plane is often not driven from one main level to the other, but from the bottom level, to the position of the first slice of the first or topmost small stage. In any case, whether the plane is driven the full distance or not, a level is set away from it, at the position of the first slice in the first small stage, and driven to the end of the panel, an inclined plane then being put up from the end of this level to the top main level. This plane, which is sometimes called a "remount," may have been

driven beforehand, down to the position of the level, to facilitate ventilation. This level having been driven to the end, and a means of ventilation thereby established, all the coal in the slice is worked off by taking a series of side lifts away from the level, to the roof and wall of the seam, and stowing put in, the level of the slice being, of course, maintained. The methods of working off these lifts, which are taken off whilst working in a back-over direction, towards the intake plane, or, in the opposite direction in which the level was driven, are as numerous as are the methods of working off a pillar of coal, in the bord-and-pillar method of Newcastle, and depend upon the thickness of the seam and state of the roof and floor of the place, as well as the hardness of the coal. These methods will be treated later. When the working of the first slice has got well started, that is, when the lifts have been begun for some time, the level of the slice above can be started, and is worked at several different points, thus enabling a number of workmen to be at work on it at once, the different places so formed going to hole into each other, ultimately, to form one level. This level may be made directly above the first one, or it may be made to the side, whichever course is adopted, making no difference to the working of the seam, although, perhaps, the timbering of the top level is easier when it is made slightly to the side of the lower one, the distance being about 20 inches ($\frac{1}{2}$ metre). This is generally the position of this level, although sometimes the level may be at a distance of 5 or 6½ feet (1½ or 2 metres) to the side. When this occurs, it is necessary to fit wooden or sheet-iron shoots into the holings, in order to run the coal down to the bottom level. When one level is directly above the other, the timber is more difficult to maintain, it being more liable to break, especially when the coal is soft. Unless, therefore, the coal is hard, it is best to avoid, if possible, one level coming over another. Whilst this is generally possible after the second level has been driven, it is difficult to avoid when driving this (the second) level, owing to the fact that the first level winds about a good deal, due to the directions of the seam being then unknown, and, the levels being constructed with a view to making them as straight as possible, the second level in course of construction may come over the first in one place and be away to the side in another.

The coal is put down on to the first level by the holings, and the ventilation of the upper level is made by hanging sheets across the lower one, and so forcing the air into the upper level. No. 2 level is generally completed some little time before the first slice is completely worked off, in which case No. 1 level which has been maintained in stowing for ventilating purposes and to bring coals from No. 2 level, is now stowed up to the point in the slice (No. 1), at which the lifts are being worked, to avoid an unnecessary length of level being left open. A small inclined plane, called a "ramp," is now made from No. 2 level down to No. 1, the lifts of the second slice are begun at the far end, and the coal obtained from here is brought along No. 2 level, over the stowing of the first slice, and down the small incline, to the first level, and so to the plane. When all the lifts in the first slice have been taken, No. 1 level is completely stowed, and No. 2 level acts in the same way as No. 1 did, No. 3 level now being begun, and so on until the first small stage is finished, when the one below is begun. The return plane of the first small stage is sometimes stowed up as the slices are finished, and opened again when the small stage below is begun and a plane put up to hole into this one. The reason for this is that it is found to be better to stow it and open it out again than to keep it in repair for all the time during which the first stage is being worked, which may be 15 to 18 months. Figs. 12, 13, and 14 (Plate XVII.) illustrate the working of the slices.

The last slice of a small stage is difficult to win, owing to the stowing from the stage above having sunk, and, the weight going towards the roof, if the seam is inclined, or, to the middle, if the seam is vertical, the coal is very much crushed. This is most pronounced in this method, because of the thickness of the seam in which it is employed. In seams in which the small stages of a panel are worked off in ascending order, this, of course, does not happen, but the small stages of this method must be worked off in descending order, as owing to the great thickness of the seam, if a big height of coal, say, 131 to 164 feet (40 to 50 metres) was left above, as would be the case if the bottom small stage was worked first, it would break, and thus, producing heat, the coal would fire. Fig. 15 (Plate XVII.) shows the sinking of the stowing (1) in an inclined seam, and (2) in a vertical seam.

In working off a lift, the chief point to be considered in determining its size is the hardness of the coal. Naturally, if the coal is soft, a large lift cannot be taken, owing to the coal above breaking down and probably causing a fire. When the coal is very hard, and the seam fairly large, as, for instance, 40 to 46 feet (12 to 14 metres) thick, four lifts are taken off at a time. These lifts are side by side, and the two middle ones, which are each 13 feet (4 metres) wide, are kept slightly in advance of the two outer ones, which are 10 feet (3 metres) wide, the total width of the set of lifts therefore being 46 feet (14 metres). Another set are started 46 feet (14 metres) away from the first set and driven in the same way, thus leaving between the two sets a block of coal 46 feet (14 metres) wide. The object of leaving this coal between the sets, is to enable two sets of lifts to be worked at the same time, and, after these sets finish, the coal left can be attacked. These lifts are stowed as they advance towards the roof or the wall of the seam, a road about 40 inches (1 metre) wide being maintained at the side of each lift for tubs and ventilation, the air going up the first road, along the set of faces, down the last road, and so on to the level. When the lifts have touched either the roof or the wall of the seam, these roads are stowed, except sometimes those left against the block of coal, which may be maintained for the working of that coal. Fig. 16 (Plate XVII.) illustrates the working of these lifts. The above method is the general way of taking off the lifts, the number of lifts in a set depending on the hardness of the coal, etc.—as, for instance, in the central district, where the coal is not perhaps quite so hard as above-mentioned, and the seam, being more inclined than in the northern district, the lifts will not have so far to go. Here, two lifts, each 13 feet (4 metres) wide, are worked away together, making one large lift of 26 feet (8 metres) wide, a road being maintained at each end. Between each set, a block of coal 20 feet (6 metres) wide is left, and, after the sets on each side of it have been worked, the coal left is taken, the roads left from the other sets being employed for the working of this coal. Fig. 17 (Plate XVII.) shows the method of working these lifts, as also the timbering employed, which will be described later.

If the coal is of a moderate hardness, two lifts may be taken side by side, one being 10 feet (3 metres) wide, and the

other, which is in advance, being 13 feet (4 metres), the block of coal left in this case being 23 feet (7 metres) wide. When the coal is soft, one lift 13 feet (4 metres) wide, is only taken at a time, the block of coal left when this happens being 23, 46, or 69 feet (7, 14, or 21 metres), according to the actual degree of softness of the coal. In this latter case, there is only one road to the lift. Where the seam becomes thinner locally, for instance 16 to 20 feet (5 to 6 metres) thick, the lift is taken off "*en direction*"; that is, the coal between the roof or wall of the seam and the level is won by a lift advancing in the same direction as the level. This method is shown in Fig. 18 (Plate XVII.), and it is also adopted when the stone of the roof or wall of the seam is bad, the reason being that in this way stowing can be put in as soon as the roof is touched, and the stone, therefore, cannot burst away, as it might do in the cross-lift methods, when the lift was approaching the roof.

When winning out the first two or three slices of the bottom small stage, it is usual to take only one lift at a time 13 feet (4 metres) wide, in order not to disturb the main level below. In the southern district, the coal was so tender that very narrow lifts had to be taken and "spiling" resorted to. Sometimes, where a large quantity of coal is required daily from one panel, two small slices are worked at the same time. The first small stage is allowed to get well away—say, to the working of the third slice—and then the second small stage is begun. When the first small stage is finished, the second one will have reached the third slice, and the third stage can now be begun, and so on. This being so, the intake plane could not deal with the quantity of coal produced, so that each small stage has a separate coal-plane of its own, besides the intake plane which serves for all the stages. These extra planes go down to the main level, and are made in the middle of the panel, the ordinary method of plane being adopted. These separate planes are put up from the bottom main level to the bottom of the various small stages, and from these points the levels of the first slice are driven away from the plane, holing into the intake plane on the one side, and going to the far end of the panel on the other, and so holing into the return plane, if it has already been made, but if not, it is immediately begun. The method of airing this level, when it is being driven, is to drive at intervals small inclined airways

to the level above, these airways being carefully stowed up when finished with. The air ascends by the middle plane, and, traversing the level, goes up the airways and on to the return level. When a holing has been obtained to the intake plane, the air ascends by it, and, traversing the level, ascends by the return plane when it has been made. When the first small stage is being begun, the second is being prepared; that is, its separate incline is being made, the level in its first slice driven, and its return plane put up, to hole, generally, into the return plane of the stage above. The main plane at the beginning of a panel is the intake airway, which is used for bringing stowing down to the faces. It may also be used for putting down coal, if need be. The return plane is, of course, the return-airway, and is also used for putting down stowing. As the stowing to be put down is proportional to the coal worked, there is necessarily a very large amount to be put down, when two small stages are going, and this plane must therefore be on the ordinary system, and, consequently, not at a high inclination. If the seam is highly inclined, the plane cannot be made in the line of dip, and therefore the bottom of the plane, owing to its inclination, would be a considerable distance away from the panel end, and proper airing of the works between it (the plane) and the panel end would be rendered difficult, so that for high inclinations it is better to have separate return planes also for each small stage working. As a rule, it is possible to make one return plane do for two small stages—owing to the inclination averaging about 40 degrees—and, therefore, the plane when completed will be a bayonette plane. Where the seam dips 25 degrees or so, one plane made in the true dip at the end of the panel will do for the whole stage.

Sometimes, when the seam is highly inclined, to save so many planes being made, one return plane is made to do for the whole stage, and a special system of working the coal from the plane to the panel end is adopted. This consists of taking the coal away, "*en direction*," in one big lift and stowing behind, maintaining two roadways in the stowing, one being the intake and the other the return, which is connected with the return plane. The intake must go away from the level before the plane is reached, to enable a sheet to be placed before the bottom of the plane. Fig. 19 (Plate XVII.) shows the working of this method, which, however, is not too good, and is only adopted in this special case.

The timbering of the level is made in the ordinary way, that is, by "pairs of gears"; these being set closely together, with thin deals put in behind the timber, where necessary, to support any loose material. The ends of the props are notched into the balk, whilst their other ends are sunk beneath the floor of the level, the props themselves being set with a slight inclination inwards towards the top. The timbering of the second level depends upon its position relative to the first. When one level is above the other, although this is not often the case, there are two methods of timbering, as shown by Figs. 20 and 21 (Plate XVII.). The first one is to erect a pair of gears, over the gears in the level below, one of the props being set exactly above one of the lower ones, whilst the other is set on the stowing, a cross-piece being placed between them at the bottom. The second method is to take out one of the props in the bottom level, and set a long prop about 13 feet (4 metres) in length, the balk of this level being notched into the middle of this long prop, whilst its top end supports one end of the top level balk; this balk is supported at its other end by a short prop set on a long bar placed longitudinally, on which latter twelve to fifteen props will ultimately be set. When, as is usually the case, the level is just to the side, a long prop is set in a hole in the floor of the bottom level, and taken up one side of the second level, supporting a top balk, which is supported at its other end by a small prop, a cross-piece being set between the props on the bottom of the second level. This mode of timbering is depicted in Fig. 22 (Plate XVII.), whilst Fig. 23 (Plate XVII.) shows the mode of timbering when the upper level is some distance to the side of the lower one. In this case, the former level is timbered by a pair of gears, the upright prop, nearest the level below, being set on a long prop placed longitudinally. The object of this prop is to prevent the upright from sinking down, owing to the easing of the stowing towards the lower level.

The timbering of a lift is very simple, long props going across the roof of the place, and set parallel to the face. These are each supported by three props, one being at each end, and the third being at 4 feet (1·2 metres) from the end at which the tub road is maintained. In this way, the road is maintained by a pair of gears, whilst deals may be put in behind the timber to support any loose stowing. Fig. 17 (Plate XVII.) shows the

method of timbering. The bottom slice of a panel is easiest to get, owing to the heaving of the bottom coal, the coal at the face consequently being broken down; but, as a result of this, much timber is broken.

The Grande Couche was formerly worked by applying the overhand-stope method across the seam; that is, the direction of advance of the working-faces was at right-angles to the strike of the seam. This was, however, abandoned, owing to the firing of the coal which used to occur. One slice lasts about three months, and one small stage fifteen to eighteen months. The hewers average 16 tubs, equal to 6½ tons, which at about 3½d. (35 centimes) per tub amounts to from 4s. 6d. to 5s. (5·60 to 6 francs) per day. The fillers average from 40 to 50 tubs each per day of 8 hours, and two stowers between them will stow 33 tubs. There are nearly always two hewers in the lifts, no matter how small the lift may be, whilst a large lift may have three or four hewers in it. There are two hewers in each face when a level is being made.

(4) *Multiple Horizontal-slice Method.*—As the name indicates, this method is an extended form of the Grande Couche method, a number of slices being taken, one above the other at the same time, instead of just the single slice, and, in this way it also resembles the vertically-stepped face method, more especially so since all the coal is taken away at one time without a level first being made, as is general when working the Grande Couche. In fact, it is simply a combination of the three methods described, and is used for seams of any inclination between 30 and 90 degrees, and of a thickness of 10 to 20 feet (3 to 6 metres). Above this thickness, the Grande Couche method can be employed, whilst if it becomes thinner it can be treated in the same manner as the Chauvetière or Couche des Littes, depending on the inclination. In other words, it is employed in seams too thick for using methods No. 1 or No. 2, and, as it is not so thick as seams worked by method No. 3, a sufficient quantity of coal cannot be obtained from a single slice, and, therefore, a number of slices are taken at the same time. This method is employed for the working of the Brûlante Nos. 2 and 3, both at Montrambert and La Béraudière, although the irregularities of these seams, especially the former, often make

it necessary to employ method No. 1 or No. 2. The same method in general is employed at the two collieries, although the details differ slightly.

At La Béraudière, panels 394 feet (120 metres) long are formed, and each panel is divided into small stages of 36 to 40 feet (11 to 12 metres) vertical height, these small stages being worked off in descending order. The stages are worked off by slices $7\frac{1}{2}$ feet (2·3 metres) taken in ascending order, three and sometimes four slices going at the same time in the small stage. An inclined plane is made in the middle of the panel, and a small inclined airway, from the bottom main level to the bottom of the first or top stage, is made at each end of the panel. Levels are now taken away from each side of the inclined plane, in the first or bottom slice of the first stage, and hole into the airways. By this means, ventilation is obtained, the air ascending by each airway, and, passing along each level, it unites, and goes to the return level by the plane. Lifts are now set away on each side of the level, and, starting from the inclined plane, are taken "*en direction*," towards the ends of the panel. These lifts are kept abreast of each other on each side of the level (if the level has been made to the side, there will, of course, only be one lift) and are stowed, the level being maintained to take coals to the plane. The second slice is begun when the first has got well started, no level being first driven in this slice. The coal in this slice is all taken away by one lift, one side of which is the roof of the seam, and the other the wall. This slice is also stowed, very often completely, though at times a level is maintained in the stowing to the plane. It is, perhaps, safer to maintain a level in this slice, but, as it can easily be done without, and, as there is trouble in maintaining it, it is not generally kept open. The coals from this slice are put down through a holing on to No. 1 level, and it is by means of this hole that the second and following slices are aired.

The third slice is treated in the same way, and is also taken away by one face, but in this case a level is maintained in the stowing to the plane. This level is kept in the middle of the stowing, and the coals of this slice are taken along it. The air coming from the second slice is brought through a holing on to the third slice. If the second slice is completely stowed, being in advance of the third, it is necessary to keep a place open in

the stowing of the second as far back from the face as it (the second slice) is in advance of the third, in order to allow a hole to be put up to this latter slice for ventilation. It is perhaps an advantage to have this holing in the middle of the face, and, therefore, the place maintained in the second slice should be made towards the wall, the distance from the centre depending on the inclination of the seam. The air ascends by the inclined airway, and goes from the first to the second face by the holings, and so on, being prevented from going along any of the intermediate levels by sheets placed on the outbye side of the holing.

No. 1 level must be maintained until the second slice is finished, when it can be stowed up, an airway being maintained at the end. The place maintained for a certain distance back in the second slice is kept open until the third slice is finished. The third slice acts in the same way for the fourth slice, as the first did for the second, or, in other words, every other slice is stowed, without maintaining a level in it. Fig. 24 (Plate XVII.) shows the working of three slices by this method.

There is a small seam in the roof of the Brûlante No. 2 seam, and about 5 feet (1½ metres) above it. Formerly this seam was worked at the same time as the larger one below it, the two seams being worked as though they were one, and the slices taken from the roof of the small seam to the wall of the larger one. Owing, however, to the thickness of stone which had to be worked, this method was abandoned, and the following method adopted for the working away of this small seam:—After three slices have been taken from the main seam, Nos. 1 and 3 levels are maintained and small cross-cuts are made from them to the smaller seam, which is now worked off by an advancing face, two levels being maintained in the stowing from the cross-cuts to the face, exactly as in the working of the Couche des Littes. There is only one face, with a level at the top and another at the bottom, the distance between them being 23 feet (7 metres) in vertical height, which is equal to the height of three slices in the main seam. The reason why this is taken after three slices in the other seams have been worked, is on account of the difficulty of ventilation which would otherwise occur if both seams were worked at the same time. In this way, the air ascends the airway in the main seam, traverses No. 1 level, goes to the bottom cross-cut, along the bottom level in the

small seam, up the face, and returns by way of the top level and cross-cut to No. 3 level, and thence to the fourth slice of the main seam, and up the working-faces. Fig. 25 (Plate XVII.) gives a section of the two seams, and shows the working.

At Montrambert, a plane is made in the middle of the panel, and the slices are begun from this plane, without driving any airways at the ends of the panel. The air ascends the plane until it arrives at the lowest working slice. Here a sheet is placed, which turns the air to right and left along the levels of this slice, and, after traversing the level, it ascends to the next slice above. The level of each slice is maintained, and coal is taken along it, whilst a small airway about 9·3 to 12·4 square inches (60 to 80 square centimetres) is maintained in the stowing from the face of a slice, as far as the face of the one above, and, in this way, differs from the method at La Béraudière, where the passage of air is obtained by holing directly down on to the level below. There are two hewers per face, and each man can hew 13 tubs, which is equal to 5·3 tons per day. The timbering is identical with that of the Grande Couche.

Sometimes when this method is being worked in the Brûlante No. 2 seam at Montrambert, the seam becomes very slightly inclined locally, besides getting thinner—perhaps down to 6½ feet (2 metres). When this occurs, it is often found convenient to adopt another method, known as the "inclined-slice method." This is simply the advancing-face method worked by slices; that is, as the seam is too thick to enable all the coal to be worked with one face by the ordinary advancing-face method, it is taken away by a series of advancing faces, one on the top of the other, the bottom one always being in advance of the one above it. The number of slices depends on the thickness of the seam. There are seldom more than three, very often two; and when the seam gets very thin, there is only one, and it then becomes the ordinary method of advancing faces, as applied in the Couche des Littes. The bottom face is in advance, and is kept stowed as usual. The second face is worked on top of this stowing, and it is stowed, the third face being taken in the same way. It is difficult to work, and the cost of timbering is very high, whilst separate levels sometimes have to be driven. Consequently it is only used here in this special case, although in other concessions,

where the seams are large and not highly inclined, it is largely employed.

Great care must be exercised in these seams (Brûlante Nos. 2 and 3) to shut off, as far as ever possible, air from the old places, and this can only be done by most careful stowing, whilst an occasional stoping, well clayed over, is sometimes necessary where a scale of air might take place. Another very important matter is to get out all the coal, no matter how difficult. These precautions are rendered necessary, owing to the excessive liability of these seams to fire. In fact, they are always exceedingly warm, and, should oxidation be allowed to go on for any length of time, owing to a scale of air passing over some coal left, a gob-fire is sure to occur, and, of course, is greatly assisted by the timber which is left in.

Such, then, are the various methods adopted at Montrambert and La Béraudière for the working of the seams, the coal of which forms a valuable gas-coal. As the greater part of the coal goes for gas-making purposes, it is not a matter of great importance to obtain round coal, which, indeed, would be rather difficult to get, owing to the tenderness generally of the coal; and, moreover, the methods themselves are not specially suitable to the getting of large coals, a fair amount of crush taking place. Of course, any large coal obtained is not broken up, but the hewers put it aside until they have got sufficient to fill a tub, for which they get paid a little extra.

IV.—Arrangement of Labour.

In every case, no matter what the method is, the arrangement of labour is the same. The day-shift workmen descend at 6 a.m. and ascend at 3 p.m., staying 8 hours at the face. The hewers simply get the coal, and do not fill at all, special men or lads being employed to fill all coal got. As has been shown, timbering forms a large part of the underground labour of the mine, and special men are employed to do this work, the hewers only doing temporary face-timbering. The latter are paid by the number of tubs they get, whilst the fillers are paid by the shift, although in some cases they must fill at least 40 tubs per shift. Their pay is from 3s. 4½d. to 5s. (4¼ to 5 francs) per day, which makes roughly 1d. (10 centimes) per tub or 2½d. (25 centimes) per ton, in places where 40 tubs of coal at least must be filled.

The timberers work by the piece, and may be paid by the metre, the price depending on the height and importance of the timbering, or by the number of gears set, the latter price being 1s. (1 franc 25 centimes) per gear. There are timberers on the day-shift as well as on the night-shift, though perhaps there are more in the latter shift, which begins at 7 p.m., finishes at 3 a.m., and is wholly taken up by timbering and stowing.

There are a great many stowers, who are paid by the number of tubs which they stow, an average being 13 to 17 tubs per man per shift. There is no putting, the fillers taking the tubs for the small distance that there is to go to the level, where horses under the charge of lads take them, either to the plane or along to the shaft, as the case may be.

If a bayonette incline is used, it requires four to six lads in each shift, whilst the winning-out of new stages, which is always taking place, requires a very large proportion of stonemen.

V.—Comparisons of Costs and Outputs of Various Methods.

It is exceedingly difficult to give any definite figures for the number of hands required per hewer in the different methods, and also to strike any averages for the output per hand employed, owing to the greatly varying conditions prevailing; but the following figures may be said to represent the hands necessary per ten hewers, and the output per hand, in the different methods, when working under average conditions:—

Table I.—Number of Hands Required for every Ten Hewers in each Method of Working.

No. of Method.	No. of Hewers.	No. of Timberers.	No. of Fillers.	No. of Stowers.	Various.	Total No. of Hands.	Output in Tubs.	Output in Tons.	Tons per Hewer.	Tons per Hand.	Percentage of Hewers.
1	10	6	5	8	9	38	170	69·7	7·0	1·83	26·31
2	10	4	6	5	8	33	160	65·6	6·5	1·99	30·30
3	10	6	5	7	5	33	160	65·6	6·5	1·99	30·30
4	10	6	4	3	11	34	130	53·3	5·3	1·57	29·41

The weight of coal in a tub is taken to be a little over 8 hundredweights (410 kilogrammes).

Table II. shows the relative costs for labour in the different methods, and also shows the timbering costs:—

TABLE II.—RELATIVE COSTS FOR LABOUR IN THE VARIOUS METHODS OF WORKING.

Item.	No. 1 Method.	No. 2 Method.	No. 3 Method.	No. 4 Method.
	Per Ton.	Per Ton.	Per Ton.	Per Ton.
Labour	4·70	4·50	4·50	5·00
Cost of timber	1·85	1·15	1·70	2·40
Totals	6·55	5·65	6·20	7·40

In each of the above tables, the figures do not include the men who are driving the winning-places in a new stage, that is, the men driving cross-cuts, inclined planes, etc. The number of these depends on the number of seams, distance from the shaft, and various other causes; but the number required is large, being at Montrambert and La Béraudière only slightly less than the number of hewers employed, although the cost is not nearly so great, owing to the fact that the labour here is not so highly paid.

An analysis of the foregoing tables shows that, whereas No. 1 method gets the largest output per hewer—due, no doubt, to the fact that there are two loose ends in the working-face—Nos. 2 and 3 methods have a larger output per hand employed, their figures being almost exactly similar. The output per hand and per hewer in No. 4 method is the lowest of all, but this is no doubt due to the extremely bad roof and wall of the seams in which it is worked—Brûlante Nos. 2 and 3. Were these (the roof and wall) as good as in the Chauvetière seam, where No. 1 method is employed, or even as good as the roof and wall of the Grande Couche usually are, the output per hewer would not be far short of that of the Grande Couche. Again, there is no doubt that the great heat in the faces of the Brûlante seams affects the hewer to a certain extent, and therefore naturally affects the output; so that it becomes difficult to compare this method with the others by means of the results obtained from the workings at Montrambert and La Béraudière.

As regards the costs of the methods, it would appear that Nos. 2 and 3 are practically equal in labour cost, the cost for timber being dearer in the case of the Grande Couche, by about 5d. (50 centimes) per ton. This is due to the fact that, whereas one has a good stone top, the other has a top of tender coal, which is crushed, and, therefore, uses very much timber.

No. 1 method is about 2d. (20 centimes) dearer in labour cost than Nos. 2 and 3 methods, whilst the timber cost is about 1d. to 2d. (10 to 20 centimes) more than that of No. 3 (Grande Couche) method, the reason, of course, being the amount of timber used in maintaining the stowing above the numerous levels.

No. 4 method, as employed in the Brûlantes, is dearer in labour cost than No. 3 method by 5d. (50 centimes) per ton, due to the reasons explained above, which also make the timber cost enormously high, being 1s. 11d. (2 francs 40 centimes) per ton, as compared with 10½d. (1 franc 10 centimes) for No. 2 method, and 1s. 4½d. (1 franc 70 centimes) for the Grande Couche method (No. 3). If the roofs of the Brûlantes and the Grande Couche were in the same state, there is no reason why the cost of timber in the one should be dearer than the cost of timber in the other.

As near as can be judged from the working of these methods (including timbering) at Montrambert and La Béraudière, the advancing-faces method is the cheapest; the single horizontal-slice comes next; the vertically stepped-face is third; and the multiple horizontal-slice is the dearest: but there appears to be very little difference in the costs—probably 6d. (60 centimes) per ton between the cheapest and the dearest, if allowance be made for the state of the Brûlante seams. However, as no two places worked by the same method bear the same proportions to each other, or have the same averages, these figures have merely been estimated from what might be presumed to be average working conditions.

An average number of hands employed in a panel working by the No. 1 method is from forty to fifty, whilst the number of hands employed in a small stage of the Grande Couche (one slice working and a level being made in the next slice) is about one hundred to one hundred and twenty, of which thirty to thirty-five will be hewers. A panel in No. 2 method will employ eighty to one hundred men, thirty of these being hewers, and a panel in No. 4 method will have sixty to eighty men.

The total cost per ton (including everything) is, at present, about 11s. 6d. (14½ francs), made up as follows:—

TABLE III.—TOTAL COST PER TON OF COAL.

	s.	d.	Francs.
Underground labour (not including stage preparations)	3	9	... 4·75
,, ,, in preparations	0	7	... 0·70
Surface labour (including screening)	0	10½	... 1·10
Materials, including 1s. 3½d. (1·6 francs) for timber ...	2	8	... 3·30
Other charges (traction, offices, salaries, etc.)	3	7	... 4·55
Total cost per ton	11	5½	... 14·40

The underground labour is made up as follows: —

TABLE IV.—COST OF UNDERGROUND LABOUR PER TON.

	Cost per Ton. s.	d.	Francs.
Hewing	0	10½	... 1·078
Filling	0	9	... 0·986
Timbering	0	10	... 1·069
Stowing	0	5½	... 0·569
Rest of underground labour	0	10	... 1·048
Total cost per ton	3	9	... 4·750

The cost of timbering is very great indeed, and is a matter which claims much attention from the engineers. The timber is got from the South of France, arriving at the collieries in lengths of 23 to 29½ feet (7 to 9 metres). Here it is cut up to the necessary sizes and sent down the pit, without being treated by any preservative of any kind whatsoever. No timber is drawn, all of it being left in when a place is stowed up. In some places, especially where driving a level in a new stage, a prop will only last a week or two, and therefore the keeping open of a level means a good deal of cost in its upkeep. The cost of timber, alone, amounts to 1s. 3½d. (1 franc 60 centimes) per ton of coal got, whilst the labour cost for timbering is from 8½d. to 10½d. (0·90 to 1 franc 10 centimes) per ton. This does not include the cost of sawing and putting down the pit, which item may be reckoned at 1d. (10 centimes) per ton; and, therefore, the total cost of timber (with labour) is 2s. 2d. (2 francs 70 centimes) per ton of coal. The cost of the timber is about 2½d. (25 centimes) per 40-inch (1-metre) length, the average diameter being 6½ to 7¾ inches (17 to 20 centimetres).

The haulage cost amounts to very little, which is principally due to the fact that gravity does a great percentage of this work. It will be noticed that materials are always descending. If it be coal, it goes to the bottom level; if it be stowage or timber, it is put down the planes to the faces from a higher level, and therefore is acted on by gravity. The only real haulage is the

taking of the coal to the shaft—and even then a slight gradient assists—and the bringing of stowing and timber to the top of the planes, and, as these distances are very short, it is entirely worked by horse labour.

Whereas materials are always descending, as a general rule, the air is always ascending the faces, which, taking into consideration the high temperature of some of the working-faces, and a certain amount of natural ventilation thus being produced, assists the mechanically-formed current of air. Partly owing to this, and to the fact that each split of air has, in no case, very far to go, the ventilating fans, mostly of the Rateau type, are only run to give a water-gauge of $\frac{3}{4}$ inch.

A vote of thanks was accorded to Mr. Annett for his interesting paper.

OLD WOODEN PUMPS FOUND IN RAINTON COLLIERY.

The President (Mr. T. E. Forster) said that the old wooden pumps found in Rainton colliery, which had been presented to the Institute by The Most Noble the Marquess of Londonderry, were now on view in the Library. From the form of the pumps he supposed that they might be about 200 years old, as he believed that cast-iron pumps only came into use in the eighteenth century.

Mr. V. W. Corbett (Chilton Moor) wrote that the pumps were found at the bottom of an old shaft about 600 feet to the south-east of the Adventure pit. There was no record of the shaft having been worked, and it had been filled up to the top, but had recently been re-opened for the purpose of a ventilating shaft. The work of boring the timber of which the pumps were made had been done most carefully, probably with tools far inferior to those in use at the present day.

Prof. Henry Louis (Newcastle-upon-Tyne) remarked that wooden pumps were largely in use in Scandinavia at the present time down to a depth of 600 or 900 feet, the sets being 30 to 36 feet deep; they were usually worked by water power transmitted by suspended wooden connecting-rods.

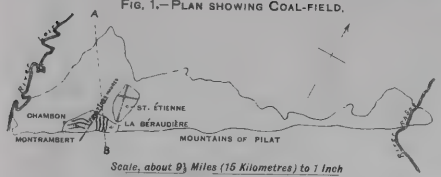
A vote of thanks to The Most Noble the Marquess of Londonderry for his gift was unanimously passed.

The Institution of Mining Engineers.
Transactions 1908-1909.

To illustrate Mr Hugh Clarkson Annett's Paper on "The Working of the Inclined Seams in the St. Étienne Coalfield, at the Montrambert and La Béraudière Collieries"

Vol. XXXVI. Plate XVI

FIG. 1.—PLAN SHOWING COAL-FIELD.



Scale, about 9½ Miles (15 Kilometres) to 1 Inch

FIG. 2.—SECTION ON LINE AB OF FIG. 1, SHOWING FOLDING OF SEAMS.

Scale, about 9½ Miles (15 Kilometres) to 1 Inch

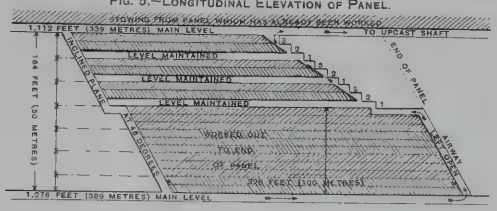
FIG 3.—SECTION SHOWING SEAMS AT LA BÈRAUDIÈRE.

Scale, about 2460 Feet (750 Metres) to 1 Inch.

FIG. 4.

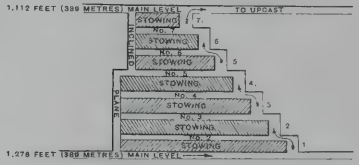
Scale, about 65½ Feet (20 Metres) to 1 Inch.

FIG. 5.—LONGITUDINAL ELEVATION OF PANEL.



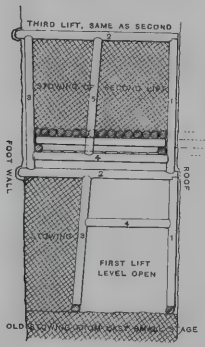
Scale, about 131 Feet (40 Metres) to 1 Inch.

FIG. 8.—SHOWING FACES IN No. 2 METHOD.



Scale, about 131 Feet (40 Metres) to 1 Inch.

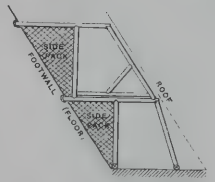
FIG. 6.—CROSS-SECTIONAL ELEVATION.



LONGITUDINAL SECTION

Scale, about 6½ Feet (2 Metres) to 1 Inch.

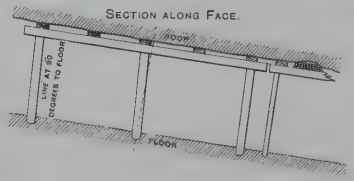
FIG. 7.—CROSS-SECTION SHOWING TIMBERING.



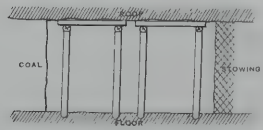
Scale, about 13 Feet (4 Metres) to 1 Inch.

FIG. 11.—SHOWING FORM OF TIMBERING IN No. 2 METHOD.

SECTION ALONG FACE.



CROSS-SECTIONAL ELEVATION.



Scale, about 6½ Feet (2 Metres) to 1 Inch.

FIG. 9.—SHOWING VARIATION IN DIP OF BRÛLANTE No. 1 SEAM.

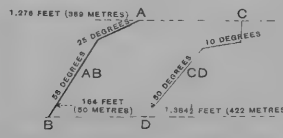
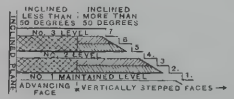


FIG. 10.—SECTION SHOWING CHANGE FROM No. 1 TO No. 2 METHOD.



Scale, about 131 Feet (40 Metres) to 1 Inch.

The North of England Institute of Mining & Mechanical Engineers.
Transactions 1908-1909.

And.r Reid & Comp.y L.d Newcastle upon Tyne

Vol. LIX. Plate II.

To illustrate Mr Hugh Clarkson Annett's Paper on "The Working of the Inclined Seams in the St. Etienne Coalfield at the Montrambert and La Béraudière Collieries"

Fig. 12.—Showing First Level of Stage and Air-plane made.

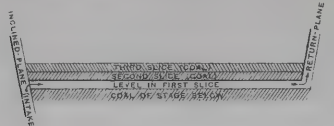


Fig. 13.—Showing Second Level Started and Lifts Begun at A in First Level.

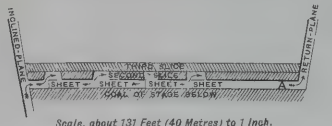
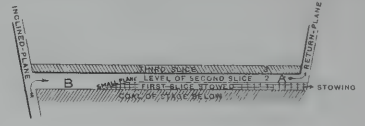
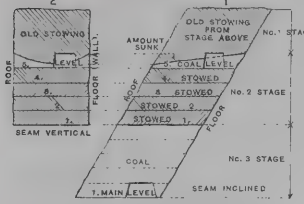


Fig. 14.—Showing Second Level Finished and Lifts Begun at A. First Level Stowed as far as B (Lifts to be taken here).



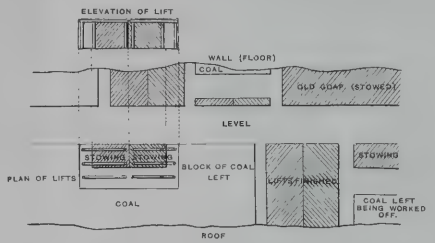
Scale, about 131 Feet (40 Metres) to 1 Inch.

Fig. 15.—Showing Sinking of Stowage.



Scale, about 65½ Feet (20 Metres) to 1 Inch.

Fig. 17.—Plan showing Working of Lifts in Grande Couche.

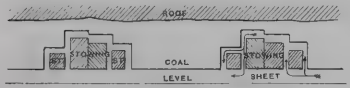


Scale, about 33 Feet (10 Metres) to 1 Inch.

Fig. 18.—Showing Lifts "en direction"

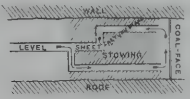
Scale, about 65½ Feet (20 Metres) to 1 Inch.

Fig. 16.—Plan showing Working of Lifts in Grande Couche.



Scale, about 65½ Feet (20 Metres) to 1 Inch.

Fig. 19.—Showing Ventilation at End of Panel.



Scale, about 131 Feet (40 Metres) to 1 Inch.

Figs. 20 to 23.—Sections showing Timbering.

Fig. 20.

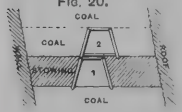


Fig. 21.

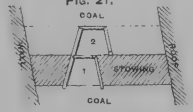


Fig. 22.

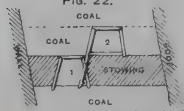
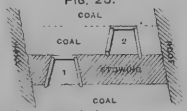
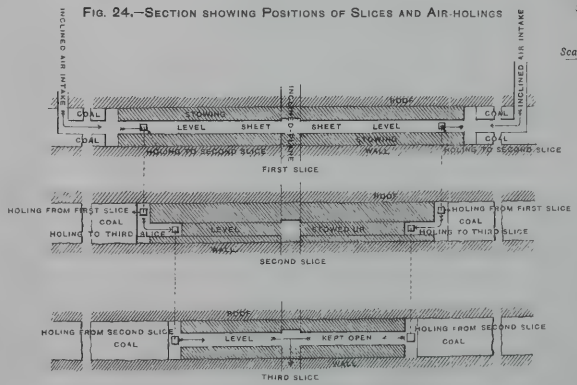


Fig. 23.



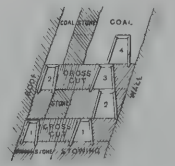
Scale, about 33 Feet (10 Metres) to 1 Inch.

Fig. 24.—Section showing Positions of Slices and Air-holings



Scale, about 65½ Feet (20 Metres) to 1 Inch.

Fig. 25.—Section showing Working of the two Seams (No. 2 Brûlante).



Scale, about 33 Feet (10 Metres) to 1 Inch.

Ard.w Reid & Comp.y L.d Newcastle-upon-Tyne

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE, FEBRUARY 13TH, 1909.

MR. T. E. FORSTER, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on January 30th and that day.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. JAMES CHAPMAN, Mechanical Engineer, 13, Queens Road, Erith, S.O., Kent.

Mr. HERBERT GREENER, Mining Engineer, Swallowhurst, Thorne, Doncaster.

Mr. ROBERT HAWXHURST, JUN., Mining Engineer, Casillas 855-856, Antofagasta, Chile, South America.

Mr. FREDERICK ALVA HORSWILL, Mining Engineer, Valley Springs, California, U.S.A.

Mr. CHRISTIAN KORTE, Consulting Engineer, Standard Buildings, 38, Park Row, Leeds.

Mr. WILLIAM LYALL, Civil and Mining Engineer, 4, Vane Terrace, Darlington.

Mr. ROBERT VAN ARSDALE NORRIS, Consulting Engineer, Wilkes-Barré, Pennsylvania, U.S.A.

Mr. JOHN PADBURY, Consulting Engineer, 2, Beaconsfield Avenue, Low Fell, Gateshead-upon-Tyne.

Mr. WILLIAM POOLE, Mining and Metallurgical Engineer, School of Mines, Charters Towers, Queensland, Australia.

Mr. WILLIAM STAINTON, Civil, Mining and Consulting Engineer, 37, South Castle Street, Liverpool.

Mr. AUDLEY HART STOW, Civil and Mining Engineer, Maybeury, McDowell County, West Virginia, U.S.A.

ASSOCIATE MEMBERS—

Mr. SAMUEL COXON, 13, Gladstone Terrace, Gateshead-upon-Tyne.

Mr. RICHARD HESKETH, Neville Hall, Newcastle-upon-Tyne.

ASSOCIATES—

Mr. MORTON HEDLEY, Colliery Under-manager, Medomsley Colliery, Medomsley, S.O., County Durham.

Mr. HENRY MOORE HUDSPETH, Mining Student, Brancepeth Terrace, Willington, S.O., County Durham.

STUDENTS—

Mr. GEORGE ALFRED HYDE, Coal Miner, 96, New Row, New Delaval, Newsham, S.O., Northumberland.

Mr. SYDNEY RAYNER, Mining Apprentice, Peases West Collieries, Crook, S.O., County Durham.

Mr. GEORGE ARMSTRONG WILLIAMSON, Mechanical Engineering Student, 101, Warwick Street, Heaton, Newcastle-upon-Tyne.

DISCUSSION OF MR. UGO BAGNOLI'S PAPER ON "REPAIRING LEAKY SEAMS."*

Mr. UGO BAGNOLI (Orbetello, Italy), replying to the discussion, wrote that the repaired locomotive was a tank-engine, the tank being placed under the boiler between the fore wheels; the cylinders were 6 inches (150 millimetres) in diameter, the stroke being 12 inches (300 millimetres). The sketch (Fig. 1)† represented the firedoor-opening, the firehole-ring being of common design; and it was not usual to chamfer off the edges of the plates, as they were generally level, as shown in Fig. 3.‡ A plate protector was contemplated, but the furnace was of too small a size to allow of a good refractory ring lining; when next repaired, however, a copper-plate ring would be inserted as a protection to the old burnt copper-plate. The furnace was a new one, but, owing to the carelessness of the fireman and some local imperfections of the metal, it was damaged. The strength of the plate, however, was not so reduced as to require a new one. A repair by caulking and the insertion of new rivets had been attempted, the holes being carefully rhymered and the rivets perfectly calibred, but, owing to the fractures and the corrosion of the copper-plate and firehole-ring, this had proved unsuccessful. He quite agreed, however, that, in most cases, it was better to rely upon caulking a seam than to depend upon any kind of cement for keeping the joint tight. When the old rivets were cut out, the copper-plate was heated and then gently hammered in such a manner as to ensure the contact surface of the seam being as clean as possible.

* *Trans. Inst. M. E.*, 1908, vol. xxxvi., page 213.

† *Ibid.* ‡ *Ibid.*, page 214.

The rivets were drilled before they were inserted, but their strength was not affected, as their diameter was increased by $\frac{1}{16}$ inch to compensate for the loss of metal. The radial hole, being only $\frac{1}{16}$ inch in diameter, became with hammering a little flat, but still open enough for the passage of the cement. Both central and radial holes were drilled at the opposite side of the riveted extremity, the former only being rhymered, owing to the pressure exerted with the holding tool during the process of riveting. Experience had proved that, when the bolt-pump was fixed in position and screwed up, percussion alone on the plunger was sufficient to force in the cement, which was not allowed to set before the bolt was released, yet was thick enough to hold itself. The boiler was tested to a pressure of 290 pounds per square inch, when the seam was found to be quite tight, the Government inspector being perfectly satisfied with it.

Mr. John H. Merivale's "Memoir of Henry Lawrence" was taken as read, as follows:—

MEMOIR OF HENRY LAWRENCE.

By JOHN H. MERIVALE.

Henry Lawrence, who was born in London on October 7th, 1825, was a son of the late Mr. William Lawrence, cashier, of London, his mother being a daughter of the late Mr. W. Easeley, miller, of Stratford-on-Avon.

Mr. Lawrence commenced his education at a private school in London, and later continued his studies at King's College.

He began his professional career as a pupil with Messrs. James Simpson & Company, of Grosvenor Road, Pimlico, London, the eminent hydraulic engineers, and one of his earliest professional recollections was in connexion with the christening of the Prince of Wales (now King Edward VII.), which took place at Windsor in 1841, where he was present as one of the employees of the above firm, who had charge of the water-supply in case of fire.

Mr. Lawrence made such progress that he was early put in charge by Messrs. James Simpson & Company of various contracts made by that firm, amongst others that might be mentioned being the Whittle Dene Water-works, which gave Newcastle-upon-Tyne its first gravity supply of water, and the mechanical engineering work connected with the docks at West Hartlepool.

Mr. Lawrence came to settle in Newcastle-upon-Tyne in 1852, taking up the position of general manager at the Ouseburn Engine-works, subsequent to which he had paid a visit to San Francisco, in connexion with the gold-mining which flourished there at that date. In those days such a voyage was a long and tedious one, and the ship on which he commenced his return journey was wrecked on a small island in the Pacific. There was no water to be found on the island, and in due time the supply obtained from the wreck ran short, but Mr. Lawrence's engineering knowledge stood him in good stead,

and, by means of tanks and other apparatus, he was able to improvise a condensing-plant, by the use of which he succeeded in distilling fresh water from the sea.

Mr. Lawrence remained at the Ouseburn Engine-works for about four years, when a position with his old firm was offered to and accepted by him. He, however, returned to Newcastle-upon-Tyne in 1860, to take up the position of manager at the Walker Iron-works, belonging to Messrs. Losh, Wilson, & Bell. He remained with this firm for eight years, when he became general manager of the Grange Iron-works, Durham, a position which he held for exactly thirty years.

Ten years ago, Mr. Lawrence resigned his position as general manager of the Grange Iron-works, and settled in Newcastle-upon-Tyne as a consulting engineer. This afforded him more leisure, but he continued to take an active interest in the various institutions with which he was connected to within a few days of his death.

Whilst at the Grange Iron-works, Mr. Lawrence, in 1878, in conjunction with the late Mr. John Daglish, patented an automatic expansion gearing for colliery winding- and other engines,* which was extensively adopted, and is at present in use on several colliery winding-engines. He also, in 1883, in conjunction with the late Mr. R. M. Ogle, patented a differential valve-gear for pumping and other engines,† which was adopted at three collieries at least in the North of England, namely, Littletown, Broomhill, and Ouston, the working in every case being most successful.

During his association with the Grange Iron-works, Mr. Lawrence established a large connexion with various South African mining companies, supplying them with a great variety of plant, including air-compressors, conveyors, etc. His general knowledge and experience were such that he was able to tackle almost any problem in mechanical engineering, and he was often able thereby to obtain a variety of work when there was any slackness in those specialities for which the Grange Iron Company, Limited, more particularly laid themselves out.

Mr. Lawrence was held in high repute as a valuer of colliery-plant, and in very many cases in the North of England where

* British patent, 1878, No. 3,812.

† British patent, 1883, No. 3,347.

collieries changed ownership he was called in to assess the value of the plant, railways, etc.

Mr. Lawrence became a member of The North of England Institute of Mining and Mechanical Engineers on August 1st, 1868, and was elected a member of the Council in the year 1882, serving on that body practically without a break until his death. He attended the meetings regularly up to the last, and took a great interest and an active part in the discussions of the various papers read before the Institute. He also contributed the following papers to the *Transactions*:—

"The Danger of Sparks produced from Prickers and Stemmers used for Blasting Purposes in Coal-mines, and Sparks otherwise Produced." *
"An Improved Watering-tub for Laying Dust in Coal-mines." †

He passed away at his residence, 13, Devonshire Place, Newcastle-upon-Tyne, on November 22nd, 1908, in his eighty-fourth year, and was buried in St. Andrew's Cemetery in that city three days later.

On the motion of the PRESIDENT (Mr. T. E. Forster), a unanimous vote of thanks was accorded to Mr. Merivale for his memoir.

Mr. EDWARD WATSON's paper on "Coal-mining on the Kirghese Steppe, in the Akmolinsk District of South-western Siberia," was read as follows:—

* *Trans. N. E. Inst.*, 1883, vol. xxxiii., page 3.
† *Trans. Inst. M. E.*, 1905, vol. xxix., page 292.

COAL-MINING ON THE KIRGHESE STEPPE, IN THE AKMOLINSK DISTRICT OF SOUTH-WESTERN SIBERIA.

By EDWARD WATSON.

The Karagandy coal-field is situated 140 miles south of the town of Akmolinsk, the capital of the district bearing the same

Fig. 1.—Russian Post-house.

name, and 450 miles south of Petropavlovsk, the nearest railway station on the Trans-Siberian railway; the longitude being 50 and the latitude 75.

The coal-field, which is, roughly, 7 miles long by 3 miles wide, is owned by the Spassky Copper-mine, Limited, London, who at present only work coal for consumption at their smelting-works at Spassky, 25 miles to the south of the coal-mines, and their copper-mine at Yuspennsky, 100 miles south. For these

purposes about 5,000 tons (300,000 poods) per month was required, but the mines are being laid out with a view to a much larger output in the near future.

Modern methods of mining, as now practised in England, are at present almost impossible in such a remote district; but in view of the probable rapid development of this enormously rich country, the writer thought that an account of his experiences, during his stay of one-and-a-half years in Siberia, might be of interest to the members of the Institute.

Leaving London early in January, 1907, the distance to Petropavlovsk was accomplished in seven days, from which place the journey was continued in a covered sleigh, drawn by three horses abreast (troicar), which also carried a stock of provisions. The drive of 500 miles, which in summer could be accomplished in three to four days, took, owing to delay with storms, ten days, changes of horses and a fresh driver being obtained at each post-house (Fig. 1), which were situated at distances apart varying from 12 to 40 miles (18 to 60 versts), the cost being about 3d. (12 copecks) per verst. All the post-houses were provided with a well-warmed and generally very clean room for travellers at night-time. Travelling night and day was at first attempted, but, after being immersed in a snow-drift for 9 hours, this was abandoned and daylight travelling only resorted to.

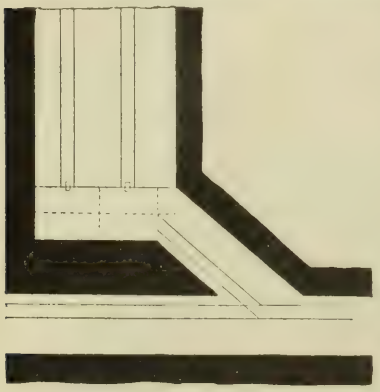


FIG. 2.—SHOWING METHOD OF LAYING RAILS ON AN INCLINE.

The writer upon arrival was shown over the various surface arrangements and underground workings by Mr. H. W. Mussen (general manager of the company, from Spassky) and the Russian manager in charge, when it was found that the seams, more especially the No. 2 or Carnot, had been worked along the outcrop, by means of small shafts, for nearly 50 years.

As at present proved, the coal-field contains four seams, all of which crop out at the surface and dip at an angle of 10 to 12 degrees in a south-easterly direction, the strike and outcrop

being north-east to south-west. The No. 2 or Carñot seam, the one that is most extensively worked, consists of a bituminous coal, which cokes well, but the percentage of ash is high, ranging from 8 to 15, the following being an average analysis:—Fixed carbon, 61·2 per cent.; volatile matter, 26 per cent.; and ash, 12·8 per cent. It is at present worked from an oblong vertical shaft, measuring 7 by 10½ feet, and 238 feet in depth, which cuts No. 1 seam at 122 feet, and, if continued, would strike Nos. 3 and 4 at approximately 660 and 1,350 feet, respectively. The average thickness of the four seams is 5, 5½, 28, and 5 feet.

FIG. 3.—IRON CHIMNEY IN COURSE OF ERECTION.

FIG. 4.—IRON CHIMNEY IN COURSE OF ERECTION.

The principal or upcast shaft is divided into three compartments, two of which are fitted with light cages, running on wooden guides, the third being the ladder-way, compulsory in all Russian mines, which contains a duplicate set of rising-mains, 4 inches in diameter, and steam-pipes, 3 inches in diameter, connected to two Worthington pumps underground, the larger having steam cylinders 10 inches in diameter, and water cylinders 6 inches in diameter, with a 10-inch stroke. This shaft is connected with others, ranging from 70 to 100 feet in depth, which form the downcasts.

Ventilation is at present produced by the heat from the steam-pipes in the shaft, and the exhaust steam from the pumps, the workings not having as yet extended to any great distance. In winter the quantity of air is regulated by doors in the intakes, but in summer these regulators are removed. Some artificial means of ventilation will, of course, have to be adopted as the workings are extended.

FIG. 5.—SHOWING HAND-WHIMS AND CHAIN-BLOCKS USED DURING ERECTION OF IRON CHIMNEY.

The system of working was a form of bord-and-pillar, which the writer changed to longwall, but, owing to objections raised by the Russian Chief Inspector of Mines, this was again changed, and a form of retreating-longwall adopted. Main levels were driven right and left from the shaft-bottom, with a parallel road for ventilation 36 feet to the rise, a main incline connecting the lower with the upper levels, 300 feet above, and also with the downcast shafts, some 600 feet to the rise. Rails were laid in the main levels, and the coal drawn down the bords on hand-sleighs, this method being found to be cheaper than laying rails in every road. A curious rule in the Russian mining laws is that the rails on an incline, worked by any form of machinery, must be disconnected from the rails on the levels below, and

FIG. 6.—IRON CHIMNEY WHEN ERECTED.

such lower levels shall be protected from runaway tubs on the incline. This is managed either by leaving a small pillar of coal (Fig. 2), or by erecting a strong timber barrier, beyond the "plates," which are compulsory to disconnect the rails. A main incline-shaft is at present being driven from the surface, on the full dip of the seam, to win the coal below the present levels, and is being laid out for endless-rope haulage.

Fig. 7.—Native Boys sorting Coal.

Steam was supplied by four old boilers of various types; but these being insufficient, a new tubular boiler of Russian make, somewhat of the Babcock-and-Wilcox type, was erected, foundations for a second being also put in, together with suitable flues and an iron chimney, 80 feet high and 3 feet inside finished diameter, the lower half being 4 feet in diameter, to allow for a 6-inch lining of fire-clay lumps. The chimney was constructed on the ground, and raised on a strong cast-iron bedplate, with hinge, by two hand-whims and blocks. Figs. 3, 4, 5, and 6 show various stages of its erection.

Fig. 8.—Loading Coal into Wagons.

The surface arrangements were very simple, the full tubs, containing about 8 hundredweights of coal, being run on a gang-

way, about 90 feet long, and tipped into an ordinary bar-screen placed at an angle of 30 degrees. If it happened that there were no empty wagons, the coal was run into stock by light tip-wagons, stones being picked out by native boys (Fig. 7). Fig. 8 shows an arrangement for loading the coal from the smaller shafts into railway wagons.

The No. 3 or Mariana seam is entered by an incline shaft, and, at a depth of 320 feet on the incline, is being laid out to work a thickness of 21 feet of coal in a series of steps, a system

Fig. 9.—General View of the Steppe.

which obtains at present in Manchuria. An average analysis is: Fixed carbon, 61·4 per cent.; volatile matter, 24·7 per cent.; and ash, 13·9 per cent. Haulage is carried out by a horse-whim, this being cheaper than steam-power, horses up to 14 hands high costing only £5 to £6 each, and hay about 10s. per ton, delivered and stacked.

Below the No. 3, or Mariana seam, is a bed of fire-clay, at least 12 feet thick, from which very good fire-bricks are being made, considering the primitive plant available.

The following is an analysis of this clay:—

	Per cent.
Silica	64·4
Alumina	23·0
Lime	0·5
Iron oxide	1·4
Magnesia	0·7
Loss on ignition	9·0
	99·0

Skilled labour is performed by Russians and the actual coal-getting by these and the native race of Kirghese. The latter are a peculiar dark-skinned people, Mohammedan in religion, and they, therefore, neither drink nor smoke. In winter they work seven days a week, but in summer drink a great deal of "Kûmiss" or fermented mare's milk, which makes them very sleepy and lazy. They are a harmless race, and when trained make good miners, but do very little per day as compared with the average English collier. The coal-drawing hours are 6 a.m. to 5 p.m.; the earnings of the men working at the coal-face vary, being from 3s. to 4s. per day for Russians, and from 2s. to 3s. for Kirghese; and the average output per person employed at the coal-face will be about 1 ton per shift. Russian skilled labour on the surface is paid for at the rate of 2s. 6d. to 3s. 6d. per day, while Russian non-skilled labour commands 2s. and Kirghese 1s. per day.

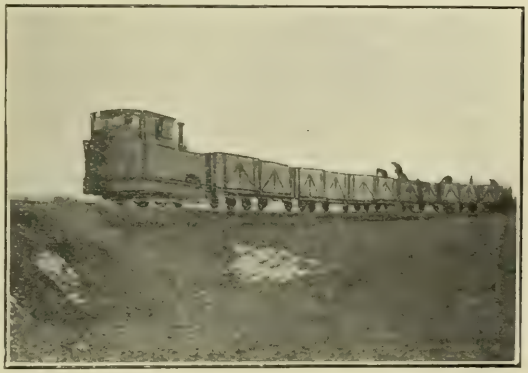


FIG. 10.—TRAIN ON THE SPASSKY-KARAGANDY RAILWAY.

The whole country (Fig. 9) is very flat for miles together, but, here and there, mountain ranges of igneous rock break the monotony; and, along the foot of these, rich copper and other mineral deposits are found. There are few rivers, the geology of the district being therefore difficult to study.

Limestone, to be burnt for building purposes, is quarried

some 4 miles north of the coal outcrops, and the writer was thus able to obtain some fair specimens of fossils, which Prof. G. A. L. Lebour, of Armstrong College, Newcastle-upon-Tyne, has been good enough to examine. He advised the writer that:—

"They were very interesting and deserved much closer investigation, and especially much wider opportunities of comparison with others in large collections, than he could possibly devote to them. It would be very rash to attempt to determine their specific names, as many of the forms were almost certainly new and not yet named. He would, therefore, only give the following list of generic determinations which were certainly accurate, namely:—

2 specimens of Crinoidal stems.

1 specimen of *Orthoceras*, a long slender form, but showing no sutures.

2 specimens (fragments) of a large turreted gasteropod, probably a *Murchisonia*.

2 specimens of a Lamellibranch, allied to *Arca*.

1 specimen of a large Rhynchonellid Brachiopod, very similar to *Camarophoria Purdoni* (Dav.).

11 specimens of three species of *Spirifera*, one of which is probably *Spirifera supramosquensis* (Nikitin).

4 specimens representing four species of *Productus*.

1 specimen of *Orthis?*

2 specimens, with several individuals of a spheroidal organism, which externally resembles the Foraminifer *Fusulinella sphæroidea*, but a thin section of which showed no internal structure of any kind. Possibly the internal chamber-partitions had been dissolved away.

2 specimens of *Lepidodendron*.

"The foregoing most interesting collection, by its general facies and the alliances of most of the species represented in it, points to the rocks from which they came forming part of the Upper Carboniferous, which in many parts of Russia and farther east contained many marine limestones alternating with sandstones, shales, and coals, as in our Northumbrian and Scottish Lower Carboniferous. The assemblage of forms was very like that which, in Russia, characterizes the zone of *Spirifera supramosquensis* in the coal-bearing Upper Carboniferous with marine limestones."

Transport is a very difficult question in such a remote district, and, when operations were first commenced, camels in the winter and horses or oxen in the summer were the only means of transport for all machinery and provisions from the Siberian railway to the works at Spassky, and for coal from Karagandy and ore from Yuspennsky. Twelve months ago, however, at the latter end of 1907, a light railway (Fig. 10), 27 miles in length, was completed between the coal-mine and smelters, which has much improved matters.

The average contract price of haulage let to natives is 8 copecks per pood per hundred versts, or 15s. 6d. per ton per hundred miles.

Extensive building has taken place at all three camps, and they are now quite large villages of 2,000 to 3,000 inhabitants, with stone and brick-built quarters for the work-people, and well-equipped stores and hospitals.

Two years ago labour was difficult to obtain, but now there are new villages springing up in all directions, which are inhabited by Russian peasants, who were in 1908 coming into this district at the rate of 40,000 per annum.

As showing the rapid development taking place in that country, the writer was able to return to Petropavlovsk by an entirely new road, some 50 miles shorter than the one upon which he travelled out, with new post-stations every 13 miles (20 versts), and, in most cases, new villages near them.

Prof. Henry Louis (Newcastle-upon-Tyne) said that the author referred to the Kirghese as being good miners who did very little work per day, which struck him (Prof. Louis) as being a contradiction in terms. He had lately had some experience in Siberia, and had arrived at the conclusion that the Russian and Mohammedan Tartar miners were amongst the worst that he had ever come across. In fairly easy country their average rate of drivage, on three shifts per day, would be, say, 5 yards a month; whereas in this country 20 to 30 yards could easily be done. He should like to know how that agreed with Mr. Watson's experience.

Mr. J. P. Kirkup (Burnhope) asked whether the author had been able to determine the geological age of the coal-field.

The President (Mr. T. E. Forster) asked whether Mr. Watson, when referring to the No. 3 or Mariana seam being laid out to work a thickness of 21 feet of coal in a series of steps, meant that it was to be worked bord-and-pillar or longwall.

Several Members having raised interesting points, it was suggested that it would be of value if the information asked for were embodied in the paper, and this the author agreed to carry out.

Mr. Edward Watson, replying, said that his remarks anent the Kirghese being good miners meant that they were good men with the wedge and heavy hammer. His experience was that

Kirghese or Russian miners would drive a "wall" or "winning-headway," 10 feet wide, 2 feet 4 inches in 24 hours, working two shifts; the Kirghese supplying four to five hewers per shift and the Russians three to five hewers at this rate. He thought that about three Kirghese would be equal to one North-country miner. The No. 3 or Mariana seam was to be worked bord-and-pillar.

In reply to Mr. J. P. Kirkup, the geological age of the coal-field was referred to in Prof. Lebour's notes on the fossils submitted to him.*

The PRESIDENT (Mr. T. E. Forster) said that the members were indebted to Mr. Watson for his interesting paper, and he had great pleasure in proposing that a vote of thanks be accorded to the author.

The vote of thanks was carried unanimously.

A new underground safety-lamp igniting apparatus was exhibited and described by Messrs. Best's Contract Company.

---

* *Trans. Inst. M. E.*, 1909, vol. xxxvii., page 131.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
APRIL 3RD, 1909.

MR. T. E. FORSTER, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on March 20th and that day.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. DAVID BOWEN, Lecturer on Mine-surveying and Geology, The School of Mines, Camborne.

Mr. ROBERT JONES, Slate-mine Manager, 11, The Square, Blaenau Festiniog.

Mr. THOMAS HENRY MICHELL, Mine-manager, Pool Mining Company, Bettws-y-Coed, S.O., Carnarvonshire.

Mr. ROBERT RICH SHARP, Mining Engineer, Riding Mill, S.O., Northumberland.

ASSOCIATE MEMBERS—

Mr. WILLIAM JAMES COCHRANE, York Chambers, Fawcett Street, Sunderland.

Mr. THOMAS MILLEN OLIFF, 321, Prince Alfred Street, Pietermaritzburg, Natal, South Africa.

ASSOCIATE—

Mr. JOSEPH THOMPSON LOWRY, Assistant Surveyor, 22, Montreal Street, Cleator Moor, S.O., Cumberland.

STUDENT—

Mr. THOMAS WALTER ADAM, Apprentice Mining Engineer, Christ Church Vicarage, Whitehaven.

DISCUSSION OF MR. HUGH CLARKSON ANNETT'S PAPER ON "THE WORKING OF THE INCLINED SEAMS IN THE ST. ÉTIENNE COAL-FIELD, AT THE MONTRAMBERT AND LA BÉRAUDIÈRE COLLIERIES."*

The PRESIDENT (Mr. T. E. Forster) said that the paper was a very interesting and exhaustive one, although the conditions described were very different from those obtaining at collieries in the North of England. It showed, however, what could be done in collieries where such great difficulties and variations were met with, and, as a consequence, a system of working be evolved, capable of being varied according to the angles at which the coal lay. The costs of working were exceedingly interesting, and he thought that, although the cost appeared to be high, the prices obtained (about which some information would have been welcome) would doubtless fully compensate for this.

Mr. HUGH CLARKSON ANNETT's paper on the "Hydraulic Stowing of Gob at Shamrock I. and II. Colliery, Herne, Westphalia, Germany," was taken as read, as follows:—

* *Trans. Inst. M. E.*, 1908, vol. xxxvi., page 394.

HYDRAULIC STOWING OF GOB AT SHAMROCK I. AND II. COLLIERY, HERNE, WESTPHALIA, GERMANY.

By HUGH CLARKSON ANNETT.

Introduction.—Although, as yet, the stowing of gob by hydraulic means has not become general in Westphalia, nevertheless, within the last few years, it has often been resorted to, and, without doubt, this method is an important factor in the extraction of coal without excessive damage being done to property on the surface. Although experimented with in Germany and in North America towards the end of last century, it was not persevered with until the year 1901, when it was adopted in a part of Upper Silesia as a means of extracting the pillars of coal left in for surface support, which, owing to the very great thickness of the seams there (26 to 33 feet, and even more), causes a very great loss of coal.

The working away of these pillars, by employing hydraulic stowing, was attended with very satisfactory results. In consequence, the use of such stowing became more general in the immediate neighbourhood, and also gradually spread to the other coal-fields, that of Westphalia being one of those to experiment with it. There it has been worked by many important collieries, notably:—Deutscher-Kaiser and Neumühl at Mülheim, Kölner Bergwerks-Verein at Altenessen, Rheinpreussen at Homberg, and Sälzer Neuack, one of the collieries of the Krupp works, at Essen. This last-named colliery was worked beneath the works, and it became impossible to continue the workings, owing to damage that was done to hearths, etc., until the adoption of the system of hydraulic stowing allowed of their being restarted. The method has been taken up of late by other collieries in the district, and has been adopted by the Hibernia Company at their Shamrock I. and II. colliery, near Herne, and it is in connexion with its working at this colliery that the writer proposes to deal.

In spite of the fact that all seams are completely stowed

by hand, there is nevertheless a serious sinking of the surface, and large sums of money have in consequence to be paid as compensation. In many cases the working of large areas of coal is prevented, owing possibly to a seam running beneath some principal street containing large sewers, or under a railway line or a church. By the adoption of hydraulic stowing, the whole of this coal may be won out, and only so slight a subsidence takes place as to cause no damage to property. At Shamrock I. and II. colliery a large area of coal has just been won out from beneath the Bahnhofstrasse the main street of the town —and at present a block of coal 109 yards (100 metres) square, which had been left as a support for the coking-plant, winding-engines, etc., is being taken away in a seam 5 feet thick.

In this way a large loss of coal is prevented, and when one thinks of the amount of coal which is left in English mines in the form of pillars—especially in mines situated near large towns—it seems surprising that hydraulic stowing has received so little consideration.

Already the method has been adopted on a small scale in various foreign coal-fields, these being, besides those already mentioned, Lower Silesia, Alsace and Lorraine, France (Pas-de-Calais), Spain, and Russian Poland.

The fact that it has been worked in Silesia, and at the Neumühl and Deutscher-Kaiser collieries, proves that it is capable of being worked in horizontal seams; and, in fact, the flatter a seam is, the greater is the advantage hydraulic stowing can claim over hand stowing, as, in the case of a highly inclined seam, a very compact stowing can be obtained by hand.

The operation itself consists of replacing the coal won out by stowing made up of small particles of stone, dirt, and sand, the dirt being obtained from the coal-washer. The stowing, in a liquid or slimy state, is brought by pipes to the point at which it is to be used, and is there flushed in with great force, thus ensuring the filling up of all spaces which cannot be accomplished by hand stowing, and, at the same time, a more or less solid mass takes the place of the coal, which, though capable of being compressed, cannot be compressed to the same extent as stowing put in loosely by hand, and the subsidence of the surface is therefore prevented. The stowing material

is deposited in horizontal layers, and the water running off is filtered before being pumped to the surface for re-use.

The slack used is made up of waste material from the heap, together with the dirt from the coal-washer, the latter being in the greater quantity. Before being mixed, it is put over a 1·18-inch (30 millimetres) mesh screen, only the undersize being used, which is mixed with water in the proportion of two volumes of water to one of slack, the water used being that pumped from the mine. The mixing is rather important, as, with too great a proportion of slack, a small hollow might be left. It is better by far to have too much water than too little, especially as the water is the means by which the stowage is transported, and this requires more water than is actually necessary to deposit the material.

The Plant.—The plant at bank consists of a large hopper, patented and manufactured by the Westphalia Company of Gelsenkirchen (Fig. 1, Plate IX.), of almost square section at the top, and becoming pyramidical towards the bottom. It is made of sheet-steel 0·197 inch (5 millimetres) thick, and is placed near Shaft I., being built upon a foundation of stone-work. The hopper is supported by four vertical supports, one from each corner, the sides being stayed by struts fixed to them and the supports. A screen, covering the whole area of the hopper, is fitted near the top, being placed at an angle of 30 degrees to the horizontal. Just above the screen, at its lowest end, a trap-door in the side of the hopper is controlled by a handle, so that it may be opened or shut at will, and at the bottom of the hopper are two hinged trap-doors, controlled by right and left worms on a shaft, engaging with toothed quadrants. These are fitted to the traps in such a way that they may be opened or shut, an opening of any size being possible, and the man in charge is able to regulate the amount of material passing through. A tippler is also provided at the top, and the material is tipped on to the screen, upon which a jet of water plays, the undersize being therefore carried through into the hopper, whilst the oversize passes down the slanting screen, and, by way of the trap-door in the side, goes down a shoot into a tub, and is taken away to be used for hand-stowing purposes. The capacity of the hopper is 35 to 40 tubs of material, and 100 tubs per hour can be dealt with.

Directly below the hopper comes the mixing funnel (Figs. 2 and 3, Plate IX.), where the slack comes into contact with water in the right proportion, and so forms the correct mixture which, owing to its nature, is capable of flowing through pipes, and in this way is not only conveyed to the point where it is needed, but, when there, spreads itself over the whole area to be stowed. This funnel, also made by the Westphalia Company, consists of a small funnel, the bottom of which rests on a pipe in the form of a ring. In this ring are four holes, which admit water delivered to it by a pipe, 3·15 inches (80 millimetres) in diameter, the amount of water passing being regulated by a cock. The shape of the ring and holes causes the water to proceed towards the centre of the pipe, where it meets with the slack coming from the hopper above, and becomes intimately mixed with the same. The apparatus is fixed to the pipes which take the stowing down the shaft. There is a possibility that the supply of water might suddenly cease, and the dry slack alone enter the pipes, which would then become choked, and cause a lot of damage. In order to prevent this, an automatic appliance is fitted, which, in the event of the water supply ceasing, closes the mouth of the pipe and so prevents the slack from entering. This appliance is shown in Fig. 2 (Plate IX.) ready for action, whilst Fig. 3 (Plate IX.) shows it after having acted and closed the mouth of the pipe. It consists of a vessel, *A* (Fig. 2), hinged at *B*, which, when standing in an upright position, forms one side of the funnel. Fixed to it is a weighted lever, which tends to turn the vessel over on the hinge into the position that it occupies in Fig. 3, that is, over the mouth of the pipe, only being prevented from doing so when the vessel is full of water, the moment due to the weight of the vessel and water being greater than that due to the weight on the lever. A small pipe coming from the main water-pipe, supplies the vessel with water, an outlet, *C*, in the bottom of the vessel allowing it to flow thence into the mixing funnel. In this way the vessel is always full of water, and therefore remains standing in an upright position, thus allowing the slack to enter. If, however, the water supply stops, the water running into the vessel also stops, the result being that it quickly empties, and the weighted lever acting turns the vessel over, and thus, by closing the mouth of the pipe, prevents the slack from entering.

Conveying Pipes.—From the mixing funnel, the material, now ready for flushing, is conveyed to the point in the mine where it is needed by means of a line of pipes going direct from the funnel, down the shaft, and along the winning-places to the face. These pipes, made of malleable galvanized iron, are in lengths of about 16½ feet (5 metres), those going down the shaft having specially welded flanges. They are jointed by placing a rubber washer between the fixed flanges, and by means of six bolts and nuts, engaging in a loose flange on each pipe, a tight joint is effected. To obviate the wearing of these pipes, due to the scouring action of the stowing material, lining pipes are put inside, in order that they may be renewed when necessary. These are made of cast-iron in lengths of about 39½ inches (1 metre), so that five lining pipes go to one outside pipe. The following are the sizes of the respective pipes:—

Pipe.	Length.	Outside Diameter.	Inside Diameter.	Thickness.	Flange Diameter.	Loose Flange Diameter.
	Ft. Ins.	Inches.	Inches.	Inches.	Inches.	Inches.
Outside ...	16 6·0	8·00	7·56	0·22	9·45	12·2
Lining ..	3 3·5	7·17	6·38	0·39	—	—

In case of a length of pipe in the shaft having to be removed for any reason, on its being taken out all the lining pipes above it would fall out, if they were fitted together in the ordinary way, and so a special fixing is made to prevent this. There is, besides the two loose flanges, a third one of the same outside diameter as the others, but of less inside diameter, this being equal to the inside diameter of the lining pipes. This flange (Fig. 4, Plate X.) is placed between the two flanges of the main pipes, which are then fixed together, the bolts passing through the additional flange. When a length of piping is to be removed, as one bolt is withdrawn a shorter one can be put in its place, and the additional flange bolted to the loose flange of the pipe above. When, therefore, a length of pipe is taken out, the lining pipes rest on this flange, and are thus prevented from falling out. This also facilitates the fixing together of the pipes.

When taken along the levels, the pipes are placed on small brick pillars about 1 foot (30 centimetres) square, which raise them about 9 inches (20 to 25 centimetres) clear of the ground.

There are two such pillars for every pipe length of 16½ feet, the centre of each pillar being about 19¾ inches (50 centimetres) from the end of a pipe. Here there is no need for the extra flange, as was the case when in the shaft, for, if a length of pipe had to be removed, there would be no danger of the lining falling out, the line of pipes now being level. As no great weight is to be borne by the flanges of these pipes, they are not welded on, but are formed by the ends of the pipes being turned over.

It sometimes happens that the pipes have to be taken along the top of the level for a certain distance, in which case they are secured by collars and held up by a strap attached thereto, the end of which is driven about 1 foot into the wall.

Whilst going down an incline, the three loose flanges have again to be used, in order to secure, as before, the lining pipes. The pipes are laid on the floor of the incline and secured about every 49½ feet (15 metres), or at every third joint. Two props are very firmly set, one end being placed in a hole in the floor, and the other end wedged up to a stout head-tree. The two props are set about a foot apart, and the pipe goes between them, the flange resting on two stout cross-pieces fixed to the props, one above and the other below the pipe.

When the pipes have reached the point at which stowing is to be done, a short curved pipe is fitted on to direct the material into the gob. This pipe is provided with the additional flange at the end, to prevent the lining from coming out.

The material is taken down the shaft in one set of pipes only, a branch going off at the third level, at a depth of 1,214 feet (370 metres), to the Dickebank seam, whilst the pipes continue down to the fourth level at a depth of 1,542 feet (470 metres), along which they go to convey the stowing for the Sonnenschein seam in the First West district, north side. As this necessitates various curves and branches, it is indispensable to have special pipes through which the material can go without clogging, at the same time causing as little wear as possible to the inner surface. Special branch pipes with two-way valves are also necessary, to enable more faces than one to be worked, although it is only possible to work one at a time.

Fig. 5 (Plate IX.) shows the pipe fitted for a branch at right-angles. In this the direction which the material must take is controlled by means of two slides, one of them having

a circular hole in it of the exact diameter of the pipe, the other being solid. These slides are each capable of fitting into the pipe at the points *A* and *B*, in such a way that, when the solid slide is at *A*, and, therefore, that with the hole in at *B*, the material flows straight on, being prevented from going to the branch by the slide at *A*, whilst it passes through the hole in the slide at *B*. When the slides are interchanged, the material then flows through the branch pipe only, being prevented from going straight on by the solid slide, which is placed at 45 degrees to the axis of the main pipe. These slides work in guides, and can be raised by means of the screw shown in Fig. 6 (Plate IX.).

A pipe terminating with branches to right and left can be worked in the same manner as the last, namely, by two slides. The main pipe terminates in a fork, or Y-piece, and to each of the free ends a curve is fitted, thus making the right angle. These curves should not be too sudden, otherwise a considerable strain is imposed upon them. The slides work in each branch pipe just near their junction with one another, and are placed at 45 degrees to the line of the limb pipe.

The slides in some cases are not used, being replaced by a partition, pivoted at the junction of the branch pipes, and these by means of a handle can be moved to the right, thus shutting off the material from that branch and allowing it to go through the left branch, and *vice versâ*.

Where a pipe must make a curve without having a branch, the curve pipe must be of a construction such as to resist, as far as possible, the greater wearing action which occurs here than in a straight length. In the case of the slight curves, a lining is put in, the thickness of metal on the outer side of the curve being greater than that on the inner side (Fig. 7, Plate IX.).

When the curve is greater (generally a right-angle), then another pipe is used, as shown in Figs. 8 and 9 (Plate X.). The radius of the inner side of this curve pipe is about 39½ inches (1 metre), and the outer side of the pipe is practically of the same radius as the inner side, or, in other words, to the outer side is given a greater bulge than the inner, thus making the pipe of wider cross-section than usual. In the inside of the pipe are fixed four or five ribs, which stick out from the concave side of the pipe in such a way as to form basins or reservoirs in which

stowing material is held. These ribs are of such a shape as to preserve the circular cross-section of the pipe, and, when the material comes in, a small amount first settles between the ribs, thus forming a lining for the outer side of the curve, and over this the material flows without coming into actual contact with the metallic surface. A curve such as this is also fitted to the pipes in the shaft at the fourth level where they come round from the vertical to the horizontal, and go along the level; but in this case it is made of cast-steel, and a stout "sole" is fitted to it. This sole rests upon a brick pillar, and thus can take a great weight (Fig. 9, Plate IX.). Every curve or branch pipe is fitted with a small circular plate bolted on to it, by the removal of which the state of the linings can be seen and also the curves—where clogging is most likely to occur—can be kept clean. All curves are also provided with screw plugs, on the removal of which a small tube can be screwed in and water flushed down the pipe. This not only has the advantage of helping in the cleaning out, but also assists the material round the curves, and gives it a greater velocity. This additional water has, however, not yet been found necessary at Shamrock I. and II. colliery.

Method of Working.—At present the coal is being taken out of a panel in the Sonnenschein seam between the main levels at 1,542 feet (470 metres) and 1,870 feet (570 metres), and is stowed hydraulically, the panel being below the coke-ovens, winding-plant, etc., whilst until recently a district in the Dickebank seam has been worked in the same way, this being beneath the main street of Herne. As this is practically finished, the writer will confine himself to an account of the working in the Sonnenschein seam only.

The method of working is not in itself different from the general method throughout the mine for this kind of seam, and is briefly as follows:—The two main levels are connected by an incline, in which tubs may run, this incline being worked by a compressed-air machine, which either lets down the coals to the bottom main level, or draws them up to the top level. Then, starting from the bottom, the coal is worked off by taking a number of faces away at right-angles to the incline, these faces varying from 33 feet (10 metres) to 66 feet (20 metres) in vertical

height, and, generally, only one is worked at a time, although there may be more. As the face advances, it is stowed behind, a road at the top being maintained to form a return for the air, so that, when this face is finished, and the face above is taken, the road so maintained forms the level by which the coal goes along to the incline. In this way the coal is taken off by means of a number of stages, one above the other, until finally the whole panel is worked out and stowing put in its place.

The coal-faces may be, and often are, worked retreating, being begun at the far end of the panel and worked towards the incline. In this case it is perhaps better, though not necessary, to have a plane at each end, the second one being a return plane, thus ensuring better ventilation and saving the driving of levels through the coal to the far end.

When a panel is being stowed hydraulically, there is always an incline at each end, the coal being won by faces retreating on the main or haulage incline. This is rendered necessary, owing to the fact that all levels should be hydraulically stowed to obtain the best results; and, by working the retreating method, this can be done, the roads being stowed up behind, as the faces come back, at the same time as the gob; whereas, if the advancing method were used, a road would have to be maintained in the stowing till a face was finished. Pipes would then have to be laid in to stow the level up, entailing extra labour and cost.

Other advantages of working in this way are, that there is no timbering to maintain in the levels through stowing; and, as it is always very wet in a level through the stowing, no haulage has to pass over a very wet road. In certain cases it may be unavoidable to work by the advancing method, and in such instances the timbering in the level through the stowing must be done most carefully; much timber is also used, adding appreciably to the cost.

The advantage of the two inclines in the retreating-face method is very pronounced when hydraulic stowing is used, the pipes being brought down the return-air incline, and thus they need not be brought past the coal-face, where there would be danger of damage by shot-firing.

The Sonnenschein seam in the First West district is between

the 1,542-foot (470 metres) and 1,870-foot (570 metres) levels, at the bottom of a syncline, the axis of which is not level, but inclined at about 5 degrees, and, as a consequence, the seam reaches the 1,870-foot level in one part, but does not reach it in another. It is the bottom of that part which dips to the south that is now being worked, the panel being taken out between the 1,542-foot level and the synclinal axis.

Fig. 10 (Plate IX.) is a plan of this district. On the west, the seam is entirely worked out, the old workings being shown, whilst a panel of coal remains between the edge of the old workings and the shaft. Part of this coal has been left in as a shaft pillar, whilst the coal west of this pillar has, as already stated, been formerly left in to support the coke-ovens, winding-plant, and other works on the surface. It has now been made possible to work the coal left by adopting the method of hydraulic stowing, and about 109 yards (100 metres) is being won out from the western part of the panel, the remainder being left as a shaft pillar. The seam is 5 feet 3 inches (1·60 metres) thick, and at the 1,542-foot level is inclined at 43 degrees, becoming less steeply inclined as the bottom of the syncline is reached. Owing to the inclination of the axis (this dipping westwards), there is 262½ feet (80 metres) vertical height of coal on the western side of this panel, and 229½ feet (70 metres) on its eastern boundary; the axis of the syncline, therefore, in this part is above the level of the 1,870-foot main winning.

The haulage incline is made on the east side, or up against the coal left in as a shaft pillar, the return incline being at the other end along the goaf edge. The bottom four levels in the old workings have not been stowed up, and these, on meeting the axis of the syncline, follow its direction, and thus run into each other, No. 4 level touching this axis at the bottom of the haulage incline, whilst it is about 29½ feet (9 metres) above it at the return incline, No. 3 level meeting it near this point. Thus at the bottom of the panel there has been left a narrow strip of coal of uneven breadth and mostly lying flat, being at the bottom of the syncline. The panel was first begun from the fourth level, the stage between Nos. 4 and 5 levels being worked first, and is now finished. As the seam between those two levels was not steeply inclined, a vertical height of 33 feet (10 metres) could only be taken, otherwise the face would have been too long.

When the stage above came to be worked, the seam became more inclined, so that it was possible to work the next two stages as one—that is, between levels Nos. 5 and 7—without the face becoming unduly long.

This stage is being worked at present, whilst the strip of coal between levels Nos. 3 and 4 has been begun, and is being worked off at the same time as the stage between levels Nos. 5 and 7. The coal from this latter stage goes along No. 5 level to the haulage incline, whilst that from the former is taken along level No. 3 to the point *A*, where a winch draws it up the small incline to No. 4 level, along which it goes through the old workings to the haulage incline, *B*, shown on the plan (Fig. 10, Plate X.).

The stowing pipes are brought from the shaft, along the 1,542-foot (470 metres) level to the return incline, down which they are taken, a branch going off at No. 7 level for that stage; whilst the pipes continue down the incline to No. 4 level, and so to the small level-stage face between levels Nos. 3 and 4, which, at its present position, is only 13 feet (4 metres) long, but which will gradually lengthen as the face advances towards the point *A*, the seam getting steeper, till at that point it becomes inclined at 23 degrees. The arrows on the plan (Fig. 10, Plate X.) denote the direction of the air-currents.

At the end of the panel next the haulage incline, a small incline is maintained at *C*. This is to allow the water from the stowing of the stage between Nos. 5 and 7 to go down to level No. 3. This incline is only small, is well timbered, and, occurring as it does at the end of the panel, great care as to stowing is not necessary. Such an incline will have to be maintained in each stage, to allow the water from the stages above to drain down to No. 3 level, along which it flows, and pass into the old workings to find its way through the hand stowing to No. 2 level, and so down to No. 1 or main level, where it goes along the levels to the sump, and is from there pumped to bank. By its passage through the hand stowing, the water is filtered and comes out clear. As the old stowing gets choked up, the water flows farther along the level and filters through, and so on. As there is a length of 984 feet (300 metres) of old workings, there is ample space for filtering.

When working regularly, a district at present is stowed every day for one hour, during which time 212 cubic feet (6

cubic metres) of material are put in. The gob is stowed by sections, one being taken after the other. The breadth of a section depends on the state of the roof, and varies from 23 feet (7 metres), when it is bad, to about 39½ feet (12 metres) when it is good. The length is equal to that of the face, which varies from 33 feet (10 metres) to 66 feet (20 metres). These sections are divided up by partitions erected in the gob, and running parallel with the face. The face is allowed to get in advance by about 39½ feet (12 metres) before stowing is put in, the roof being timbered in the meantime. The partition is erected by means of props set from 12 inches (30 centimetres) to 16 inches (40 centimetres) apart, the bottom being placed in a hole in the floor, and the top wedged tightly up to a plank. Cross laths, about 9 inches broad, are then nailed on to these props, being placed 1½ to 2 inches apart. Brattice-cloth is hung over the gob side of the partition, care being taken that it is tight up against the roof and floor. This partition being erected, the stowing can now be commenced, and, coming in at the top at high velocity, it is spread evenly over the breadth of the section. The only escape for the water is through the cloth and between the planks, running down the floor of the seam to the level below, and going, as already described, to the sump. Care must be taken that there is no hole in the cloth, this providing a ready means of escape for the stowage, which pours through and blocks up all the levels. A man must always be engaged, during actual flushing, in watching this cloth, and, by poking it, in keeping the solid material from choking it and preventing the water from escaping. Cloth threaded with thin wires has been tried with the idea of strengthening it, but this did not appear to be of any advantage. Fig. 11 (Plate IX.) shows the partition, and Fig. 12 the relative position of the face to the sections.

The timbering is effected by ordinary stemples, with occasionally a plank at the top, and placed about 39½ inches (1 metre) apart. These props are regained from the gob, except when the roof is bad, a line always being withdrawn before flushing commences. Adjustable iron props are often used, and answer very well where the seams are not at too high an angle. The partition props are not, however, withdrawn, but are left in to support the stowing. It is possible that, if the stowing has set solid enough before the next section is stowed, these partition

props may be recovered. In the Sonnenschein seam the stone is very good, and all props can be regained. On starting a new face here, a very stout partition must be made along the return incline to prevent leakage when the first section of a stage comes to be stowed. This is made by props set as in the erection of the ordinary partition, and planked on the inside by stout planks set tight up to each other. If a level has to be maintained through the stowing, a similar partition must be erected on the high side, in order to maintain the stowing above, as shown in Fig. 13 (Plate IX.). Communication is made between the face and the mixer at bank by means of a telephone, which enables the man in charge there to regulate the supply. When the stowing is to be begun, the workman at bank receives the signal, and begins by turning on the water and allowing it to run for about 5 minutes before admitting any slack. This is done as a precaution to clear the pipes and prevent sticking. When stowing is finished, water is again run through the pipes, which in this way are kept quite clear.

Costs.—The following figures give the cost of the plant, and the working costs in the district described and in another district which is now finished:—

A.—Surface.

	£	s.	d.	Marks.
Hopper	112	5	0	2,245
Mixing funnel	19	0	0	380
Pipes and valve for mixer	6	18	0	138
Pipes from pump	11	17	0	237
Total	£150	0	0	3,000

B. Underground.

(1) *Shaft.*

	£	s.	d.	Marks.
94 pipes to 1,542-foot (470 metres) level, each 16½ feet (5 metres) long, at 116·10 marks ...	545	13	5	10,913·40
1 sole curve at the 1,214-foot (370 metres) level	17	16	2	356·15
1 sole curve at the 1,542-foot (470 metres) level	17	16	2	356·15
2 stop-cocks	10	6	0	206·00
Labour in fixing, at 6·32 marks per metre (39½ inches)	148	16	8	2,976·72
Total	£740	8	5	14,808·42

(2) *In 1,214-foot level, to Dickebank Seam (1,312 yards).*

	£	s.	d.	Marks.
240 pipes, at 112·45 marks	1,349	8	0	26,988·00
2 branch pipes	19	19	0	399·00
14 curves	54	4	7	1,084·60
2 pipes with screw plugs for additional water ...	4	16	0	96·00
7 collars and straps for pipe supports, at 2 marks	0	14	0	14·00
Labour in fixing, at 2·10 marks per metre (39½ inches)	126	0	0	2,520·00
Total	£1,555	1	7	31,101·60

(3) *In 1,542-foot level, to Sonnenschein Seam (678 yards).*

	£	s.	d.	Marks.
124 pipes, at 112·45 marks	697	3	9	13,943·80
1 right-and-left branch pipe	11	15	0	235·00
2 branch pipes	19	19	0	399·00
9 curves	31	16	1	636·10
23 collars and straps for pipe supports, at 2 marks	2	6	0	46·00
Labour in fixing, at 2·10 marks per metre (39½ inches)	65	2	0	1,302·00
Total	£828	1	10	16,561·90

Total Cost of Plant and Fixing.

	£	s.	d.	Marks.
Surface	150	0	0	3,000·00
Shaft	740	8	5	14,808·42
In 1,214-foot level	1,555	1	7	31,101·60
In 1,542 ,, ,, ...	828	1	10	16,561·90
Total	£3,273	11	10	65,471·92

Total Cost of Labour for Fixing.

	£	s.	d.	Marks.
Shaft, at 6·32 marks per metre (39½ inches) ...	148	16	8	2,976·72
In 1,214-foot level, at 2·10 marks per metre (39½ inches)	126	0	0	2,520·00
In 1,542-foot level, at 2·10 marks per metre (39½ inches)	65	2	0	1,302·00
Total	£339	18	8	6,798·72

The cost of plant alone is therefore £2,933 13s. 2d. (58,673·20 marks).

Working Costs, etc.

Cost of stowing a face hydraulically in Sonnenschein Seam, October, 1908.

Working days	27	
Output	1,742·95	tons.
Average output per day	64·55	,,
,, ,, ,, hewer	6·03	,,
,, ,, ,, workman at face	3·10	,,
Hewers	12	
Other hands	10	
	22	
Cost per ton for hewing	1s. 2d. (1·15 marks).	

WORKING COSTS, ETC.—*Continued.*

	£ s. d.	Marks.
2 men on surface, working 1 hour per day ...	2 14 0	54·00
4 ,, underground preparing partitions, moving pipes, etc.	29 11 5	591·40
Cost of wood for partitions	13 10 5	270·40
,, cloth ,, ,, ...	2 8 0	48·00
,, nails ,, ,, ...	0 2 0	2·00
Pumping 201,465 cubic feet (5,704 cubic metres) of water to surface, at 0·065 mark	18 10 9	370·76
Depreciation on plant: 10 per cent.	10 5 0	204·98
Total	£77 1 7	1,541·54

The output of coal was 1,742·95 tons, making the cost per ton for hydraulic stowing 10·608d. (0·884 mark).

Cost of stowing a face hydraulically in Dickebank Seam, July, 1908.

	£ s. d.	Marks.
2 men on surface, working 1 hour per day	2 14 0	54·00
2 ,, underground preparing partitions, etc.	13 1 7	261·61
Cost of wood for partitions	8 11 9	171·80
,, cloth ,, ,, ...	1 18 0	38·00
,, nails ,, ,, ...	0 2 0	2·00
Pipe shifting	2 18 0	58·00
Cost of working a small pump and cleaning out of a sump	6 0 6	120·47
Pumping 277,513 cubic feet (7857·12 cubic metres) of water to surface, at 0·065 mark	25 10 9	510·71
Depreciation on plant: 10 per cent.	17 0 7	340·61
Total	£77 17 2	1,557·20

The output of coal was 1,718·75 tons, making the cost per ton for hydraulic stowing 10·872d. (0·906 mark).

	d.	Marks.
Cost of hydraulic stowing: Sonnenschein Seam ...	10½	0·884
,, ,, : Dickebank Seam	10¾	0·906
,, hand stowing: average for mine	7½	0·630

The cost of stowing in the Dickebank seam is higher than that in the Sonnenschein seam, owing to the fact that the stowing has to be taken in a longer distance, and, in addition, the pumping up of the water costs more, because it has to be pumped to a sump where it becomes clear before going to the main sump to be pumped to bank. This is necessary, as there are no old hand-stowed workings to bring the water through to be filtered. The depreciation on the plant is taken at its very highest, for, as yet, the amount of wear on the pipes is unknown, and it is also high because the plant is not working regularly; at the most, 3 to 4 hours per day. The depreciation has been reckoned as follows:—

As there are two districts in the Dickebank seam and one in the Sonnenschein seam, the cost of the plant on the surface and in the shaft, as far as the 1,214-foot level, has been divided up in such a way that two-thirds is against the former seam and one-third against the latter. Added to these costs are the respective costs of the piping in each seam; and 10 per cent. of the cost against each seam is the amount written off as depreciation in the working costs of that seam.

From the above costs, it will be seen that, with regard to actual working costs at Shamrock I. and II. colliery, it is from 3d. to 3·33d. (0·25 to 0·28 mark) per ton of coal dearer to stow hydraulically, than to stow by hand. In these costs, however, the amount to be paid in compensation, when hand stowing is used, is not included, so that the difference in the cost is not so great, and would be still less if the hydraulic stowing were worked more regularly and extensively. As an example of how the cost is lowered when this method is worked on a large scale, two collieries in Silesia belonging to the Kattowitz Colliery Company may be cited. These collieries work very large seams —one of them being about 62½ feet (19 metres) thick—and hydraulic stowing has been adopted with exceptionally good results. One of them—the Ferdinand mine—has at present only adopted the principle on a small scale, and the cost is 8d. to 9d. (0·70 to 0·80 mark) per ton of coal, whilst at the other—the Myslowitz mine—where this system is adopted throughout the entire mine, the cost is only 5d. (0·42 mark) per ton, although the conditions underground are almost practically the same as at the Ferdinand mine.

Linings.—Although this method has been working for about two years at Shamrock I. and II. colliery, it has not as yet been employed regularly, and consequently sufficient time has not elapsed to provide any means of ascertaining how long the linings will last before having to be renewed. In the meanwhile, as an experiment, linings of porcelain are being tried. A few pipes with a lining of brown hard-burnt porcelain, 0·4 inch (10 millimetres) thick and in lengths of about 33 feet (10 metres), and a few with white porcelain linings, 0·4 inch (10 millimetres) thick and in lengths of 16½ feet (5 metres), have been inserted. The cost of the brown porcelain lining is 3s. 9d.

(3·75 marks) and that of the white porcelain 14s. (14 marks) per metre (39½ inches).

Experiments on the durability of linings have been carried out at the Deutscher Kaiser colliery, in Westphalia, where hydraulic stowing is employed very largely, and a coarse sand used as the stowing material, 1,200 to 1,300 tons being utilized per day. White porcelain had been in the pipes for 3 years, and had passed 90,000 tons of material, and it only appeared to be half worn. Glass linings, costing 10s. (10 marks) per metre (39½ inches), passed 60,000 tons before being worn out, earthenware also passing the same amount. A cast-iron lining only passed 16,000 tons, but appeared to have been of poor quality, and another special kind passed 60,000 tons before having to be taken out.

When sand is used, it does not appear to give the same amount of trouble as washer-slack when being deposited, probably because it is heavier and is deposited in horizontal layers, the water on escaping containing very little solid material, thus causing less trouble with the canvas of the partition and enabling the planks to be set farther apart. This sand sets into a solid mass, and a road can be driven through it with ease.

At the Myslowitz mine, in Silesia, linings of hard wood were used, pieces about 8 inches (20 centimetres) long being fitted round the inside of the 39½-inch (1 metre) pipe by means of a hydraulic ram. The cost of these linings is 2s. (2 marks) per metre-length, and they pass 400,000 to 450,000 tons; whilst some iron linings which were formerly used did not pass as much and cost 12s. (12 marks) per metre. At this mine the cost of hydraulic stowing, 5d. (0·42 mark), is less than that of hand stowing.

At the Ferdinand mine, boiler-ash, zinc-ash, small stones and pieces of brick were all used as stowing material. In this way, there is not so much small stowing, and cloth on the partitions is dispensed with, the boards being set close together. This mixture is severe on all kinds of linings, and the iron linings used here, 0·315 inch (8 millimetres) thick, pass about 35,000 tons before being changed. At the Florentina mine, in Upper Silesia, hydraulic stowing on a small scale is employed, and costs 7d. (0·60 mark) per ton. The Cleophas mine, also in Upper Silesia, uses no linings; but, when the pipes wear out, a

piece is fitted over the hole and put on by means of the oxy-hydrogen flame. This is said to be cheaper than re-lining.

One of the remotest districts in the Shamrock I. and II. colliery was, for a time, hydraulically stowed, the method being the same, excepting that the slack was brought into the mine in tubs and taken to the district, where it was placed in a funnel and mixed. This was, however, abandoned, owing, in the first place, to the excessively high cost of haulage, and secondly, because the water caused the heaving of the floor.

Advantages.—The advantages attached to the use of hydraulic stowing are:—

(1) The stowing is more compact, and therefore gives less shrinkage of surface. It has been estimated that, whereas there is a shrinkage of 40 to 60 per cent. when hand stowing is employed, this is reduced to 10 and even to 5 per cent. by using hydraulic stowing.

(2) The roof is supported better by reason of the evenness of the stowing, and is kept more to the good, and this consequently minimizes the danger of accidents.

(3) There is a saving of timber.

(4) There is less danger of fire, due to the stowing being compact and preventing scale of air through it.

(5) There is a gain in the quantity of coal, by working pillars which otherwise could not be got.

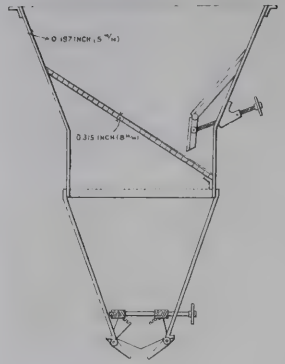
(6) There is less waste in the big seams.

(7) The advantage of face ventilation, the air being forced to come along it, instead of scaling through the stowing.

In conclusion, it has been proved in Germany that hydraulic stowing can claim many advantages over hand stowing, and, at the same time, the cost is not prohibitive, as an average cost would appear to be 6d. to 7d. per ton in mines where material is easily got, and slightly dearer where the material is more difficult to obtain, as at Shamrock I. and II. colliery, where the cost per ton for this stowing is well above the average. It might be adopted in some mines in England with advantage, and it would be especially interesting to know how collieries working undersea coal and those near towns would be affected by the application of this method.

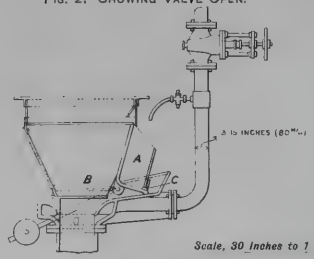
To illustrate Mr. Hugh Clarkson Annett's Paper on "Hydraulic Stowing of Gob at Shamrock Land II. Colliery, Herne, Westphalia, Germany."

FIG. 1.—SHOWING HOPPER.



Scale, 70 inches to 1 inch.

FIG. 2.—SHOWING VALVE OPEN.



Scale, 30 inches to 1 inch.

FIG. 3.—SHOWING VALVE SHUT.

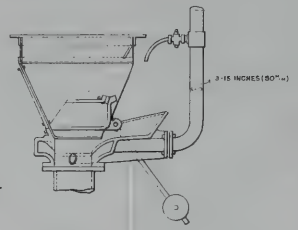
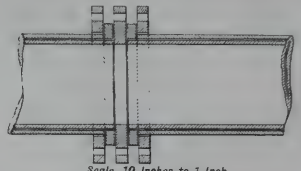
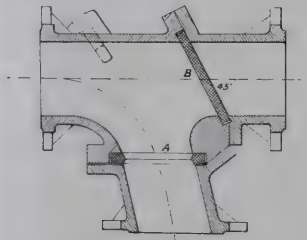


FIG. 4.—SHOWING LOOSE FLANGE.



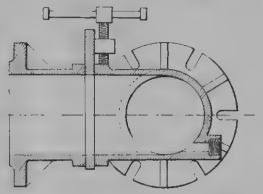
Scale, 10 inches to 1 inch.

FIG. 5.—SHOWING SECTION OF BRANCH PIPE.



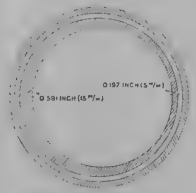
Scale, 11 inches to 1 inch.

FIG. 6.—SHOWING SECTION OF BRANCH PIPE.



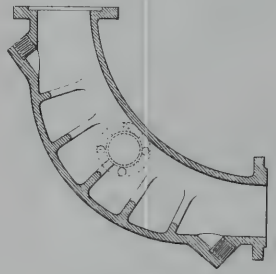
Scale, 11 inches to 1 inch.

FIG. 7.—SHOWING SECTION OF CURVE.



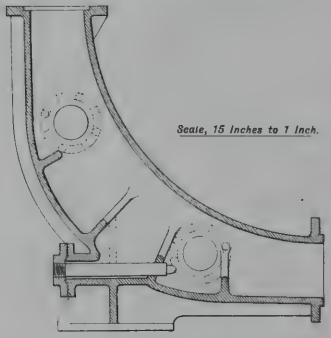
Scale, 5 inches to 1 inch.

FIG. 8.—SHOWING SECTION OF CURVE.



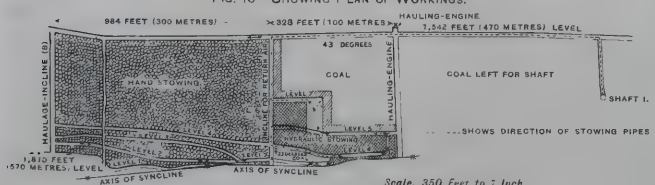
Scale, 15 inches to 1 inch.

FIG. 9.—SHOWING SECTION OF CURVE.



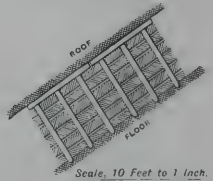
Scale, 15 inches to 1 inch.

FIG. 10.—SHOWING PLAN OF WORKINGS.



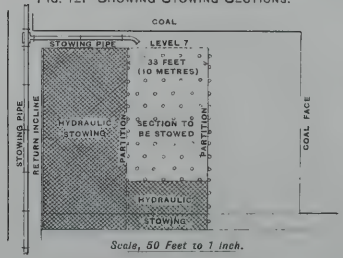
Scale, 350 Feet to 1 Inch.

FIG. 11.—SHOWING PARTITION.



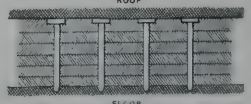
Scale, 10 Feet to 1 Inch.

FIG. 12.—SHOWING STOWING SECTIONS.



Scale, 50 Feet to 1 Inch.

FIG. 13.—SHOWING TIMBERING FOR LEVEL.



Scale, 10 Feet to 1 Inch.

And.r Reid & Comp.y Ltd. Newcastle upon Tyne

The President (Mr. T. E. Forster) said that the subject of the paper was probably becoming of increased importance, although he did not think that the conditions (like those of the St. Étienne coal-field) were applicable to their own district. The system, however, was beginning to be introduced into England. There was an iron-ore mine at Cleator Moor, in West Cumberland, which was, at present, being partly worked on the system described, sand being run into the old workings, so as to get out the pillars of ore which had been left under buildings; and he thought that, if the system proved a success, a visit to the mine at some future date might be of interest. Eventually it might be adopted in coal-mines where there was a lot of loose refuse, which could be stowed underground at a comparatively low cost. The cost of hydraulic stowing given by the author was very interesting, especially to those who were working under buildings, because there was no doubt that such stowing strengthened the ground and made the subsidence very much less than usual. He thought, from what he had read in the paper, that it was a very small fraction indeed, as compared with that due to ordinary methods of working.

A vote of thanks was unanimously passed to Mr. Annett for his interesting paper.

Mr. T. G. Noble, in the unavoidable absence of the author, Mr. W. C. Blackett, read the following "Notes on a Small Contrivance to more easily Detect Fire-damp":—

NOTES ON A SMALL CONTRIVANCE TO MORE EASILY DETECT FIRE-DAMP.

By W. C. BLACKETT.

Considerable discussion has recently taken place as to the manner in which examinations are made in order to detect the presence of fire-damp, and it has been observed that there is a great difference between individuals, both in their powers of detecting small percentages and in their methods of using the flame of the safety-lamp. Practice no doubt largely affects the former, but as to the latter, there is really no reason why everyone should not be on the same footing.

Recently it had been held that, in order to detect the smallest possible percentage of fire-damp, the examination should be carefully made with the lamp flame so drawn down that it shows blue only, no white light whatever being visible. Examiners for fire-damp thus either risk the danger of losing their lights, or of being subjected to the charge that the examination is effected with a flame so high that indications of fire-damp, except in higher percentages, cannot be properly observed.

The writer wishes to point out most emphatically that small percentages of fire-damp can be seen quite as well, and even better, with a lamp flame that is somewhat high and shows a small white light, than with a flame which shows only a blue light. It is necessary, however, that the white light should be shielded from the eye, and, if this is done, a very much longer cap is to be seen than with the small flame which shows only blue; with 3 per cent. of gas it is much more than twice as long.

Practical men have always recognized this, and it is a common occurrence to shield with the thumb the white speck of light, and so more easily observe any cap.

The writer has, however, found it more convenient to effect this by the fixing of a small shield inside the lamp (about half an inch from the flame) either to the pricker or to the wick-pipe. This, of course, allows of the use of a higher flame, and so

To illustrate Mr. W. C. Blackett's "Notes on a Small Contrivance to More Easily Detect Fire-damp."

FIG. 1.—AIR ONLY, AND 1 PER CENT. OF MARSH GAS.

FIG. 2.—2 PER CENT. OF MARSH GAS.

FIG. 3.—2½ PER CENT. OF MARSH GAS.

FIG. 4.—3 PER CENT. OF MARSH GAS.

FIG. 5.—4 PER CENT. OF MARSH GAS.

And.w Reid & Comp.y Ltd. Newcastle upon Tyne

reduces the risk of losing one's light, and, at the same time, proves more effective in the detection of fire-damp. The writer recommends the use of a lamp so constructed in all fiery mines.

In the detection of gas the writer has failed to find any advantage in the use of blue glass; but a magnifying glass, whether blue or clear, he has most certainly found helpful. Anyone who is accustomed to read with spectacles should use them also when examining for gas.

The writer has also found that if the inside of a suitable portion of the lamp glass be ground, the reflection which sometimes interferes with proper observation of the flame will be avoided.

The subject of fixing some standard test in regard to the presence of gas in mines is occupying the attention of the Royal Commission on Mines, and in connexion with this the writer has recently been afforded an opportunity by Dr. Bedson, at Armstrong College, of observing the appearance of safety-lamp flames in the presence of known quantities of marsh-gas; and, by the courtesy of the North of England United Coal Trade Association, he has been enabled to reproduce coloured illustrations of various caps, due to the presence of varying percentages of marsh-gas, as they appeared to his eye (Figs. 1 to 5, Plate X.).

Mr. T. G. Noble (Sacriston) said that Mr. Blackett had asked him to express his (Mr. Blackett's) regret at not being able to be present; he had also requested him to read the foregoing notes, and to exhibit to the members lamps with the shield attached. The lamps were of an ordinary type, made by Messrs. Ackroyd and Best, the shield in one being attached to the pricker and in the other to the wick-pipe.

Continuing, in reply to several questions, Mr. Noble said that if the shields were of uniform height, a standard flame would be more easily assured when the light was drawn down to the height of the shield, and the lamp placed on a level with the eye. Lamps were now being fitted with the contrivance for use by all their shot-firers and deputies.

Mr. Simon Tate (Trimdon Grange) said that he had had several conversations with Mr. Blackett upon the question of

the detection of fire-damp, and Mr. Blackett had designed this shield, owing to the difficulty that they both felt was experienced by examiners for gas with too small a flame, which so readily went out. There was no doubt that examiners were very much afraid of losing their lights. He did not know what the contrivance would be like in practice, but men would be able to test for gas with a much larger flame, and whether a movable or fixed shield were employed, he thought that the device was a great improvement on the present system.

Mr. William Rutherford (Gateshead-upon-Tyne) said that it was putting into a mechanical form the idea of the old men who used to examine for gas with candles, and who put their hands in front in order to shut off the white light.

Mr. William Severs (Beamish) said that he was not at all sure whether one would not sometimes be able to find gas better with a light up than with it down, as there might be a stratum of gas that was hanging near to the top of a place, which could not be got at if the light were drawn down into the wick-pipe; but if the light was of normal size, the gas might be detected by the flicker of the light. It did not seem to him that it was very necessary to know whether there was 1, 2, or 3 per cent. of gas present, as if gas, no matter in what quantity, was detected in any place, in his opinion that place should be fenced off, and not wrought until it was cleared.

Mr. W. B. Wilson (Easington) said that he thought a very great deal depended on the place in which one was examining for gas. If for a small percentage in a return air-current, a very much reduced flame was the proper thing to use. If examining for gas in, say, a ripping near the coal-face, a larger flame might with advantage be used. The danger of lowering the light would be greatly increased by using a small blue flame in the latter case.

The President (Mr. T. E. Forster) said that Mr. Blackett's contrivance was one which everyone should welcome, as there was no doubt a tendency to test for gas more elaborately than in the past. If they read the reports of the evidence taken before the Royal Commission on Mines, they would see what

was in Mr. Blackett's mind; and if they could improve testing with an ordinary safety-lamp, without fear of losing their light, he thought that it would be a great boon and a blessing to colliery managers and owners. He would suggest that everyone should try the appliance, to see whether it would turn out in practice as well as it promised, and the results might be communicated to the members when Mr. Blackett's paper came up for discussion.

Mr. Noble said he thought that Mr. Severs had rather missed the point of the contrivance. Although the particular lamp that he was using did not draw the air from the top, lamps could be constructed in that way, and so enable one to test close to the roof; but what he wished was to train men to know approximately what percentage of gas was present by means of a constant amount of flame.

The President (Mr. T. E. Forster) asked whether the point was not also to enable one to test for small percentages of gas with a larger flame than had been used heretofore.

Mr. Noble agreed that that was so.

Mr. J. H. Nicholson (Blyth) said that in the old days the deputies, when testing for gas, used a specially small candle, the exact size of which, however, he was unable to remember.

Mr. Rutherford said that the number was 14 to the pound.

Mr. John H. Merivale (Broomhill) said that the suggested appliance was really a very old idea. He remembered that, when he was a student at the Durham College of Science, during the session 1871-1872, someone suggested the idea, and, being young and enthusiastic, he got one made by Mr. H. B. Watson, of the High Bridge, Newcastle-upon-Tyne. The lamp was made, and he and his friends tried it; whether, however, it was their fault or the fault of the lamp he could not say, but the matter fell through, and nothing more was heard of it. He was rather afraid that they would find the same result with Mr. Blackett's little arrangement, although everyone hoped that such would not be the case.

The President (Mr. T. E. Forster), in proposing a vote of thanks to Mr. Blackett, said that they had to look to different conditions in the future from those with which they had dealt in the past as regarded gas in mines. People were already talking of testing returns, and contrivances and observations of this kind, which showed that they were alive to the danger, might possibly avert some more drastic form of legislation than they had experienced up to the present.

The vote of thanks was unanimously passed.

READING, WRITING, AND SMOKE ROOMS.

The President (Mr. T. E. Forster) said that he would like to draw the attention of the members to the fact that the two rooms adjoining the Lecture Theatre were now fitted up as reading, writing, and smoke rooms, and that on ordinary occasions when there was no meeting being held in the Lecture Theatre, access to them would be by the spiral staircase from the Library.

The International Rochester Time Recorder was exhibited and described.

THE INSTITUTION OF MINING ENGINEERS.

THIRTEENTH ANNUAL GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
SEPTEMBER 17TH, 1902.

MR. JAMES S. DIXON, RETIRING-PRESIDENT, IN THE CHAIR.

The following paper on "Coal-shipment and the Laying-out of Staithe Heads, with Special Reference to Anti-breakage Appliances," by Mr. John Kirsopp, Junior, was read at the above meeting,* but was not then printed in the *Transactions*, and has since been rewritten and brought up to date for publication:—

* *Trans. Inst. M. E.*, 1902, vol. xxiv., page 582.

COAL-SHIPMENT AND THE LAYING-OUT OF STAITHE HEADS, WITH SPECIAL REFERENCE TO ANTI-BREAKAGE APPLIANCES.

By JOHN KIRSOPP, junior, F.G.S.

I.—Introduction.

Although at the outset the writer expresses an apology for attempting to tabulate and review this subject, he has been led to do so after a tour through Canada and the United States, where he was impressed by the rapidity in the rate of shipment effected there, as compared with the speed on this side of the Atlantic.

Traffic Conditions between Colliery and Loading Wharves.—In the colonies, existing conditions are vastly different. The American and Canadian principle is to erect bunkers as near to the shipping wharf as possible, these being always kept well filled with coal; and little or no regard is paid to breakage. A steamer arriving for loading, in addition to having the tonnage from the pits brought direct to the teeming spouts, has a constant auxiliary feed brought from the bunkers; and this requires the staithe heads to be laid out to the best possible advantage for the rapid handling thereon of the wagons.

In this country, collieries may be classed under four divisions:—(1) Those contiguous to and having their own private railway between the pits and the staithe head; (2) those which are dependent on a railway company for both traffic and shipping facilities; (3) those which are partly dependent on the North-eastern Railway Company (which include many of the Northumberland collieries), being places which can ship from two or more staithes on the Tyne or from Blyth in addition; and (4) those having

an entirely inland house- and gas-coal trade, that is, the majority of collieries in Yorkshire, Lancashire, and the Midland coal-fields.

In the Northumberland and Durham coal-field, a few collieries come under the first division, where the old-fashioned chaldron-wagon is or was in operation, although within recent years some owners have abandoned this type in favour of a larger wagon of 10 tons capacity. Consequently, unless these private staithes are fed by the output of several large pits, there is little advantage in a speedier rate of shipment thereat than is required by the usual colliery guarantee, as they are well within the margin of the limited daily output of the colliery. The majority of collieries, however, come under the second class, the monopoly of the two counties being held by the North-eastern Railway Company, who own and operate all the wagons running over their lines from collieries within such monopoly, the mileage rate being fixed by Parliament, and no additional rate is charged for wagon hire. This custom originated probably at the time when the company sought powers to construct the line, in order to stave off opposition, and on account of certain collieries owning old leases which granted them certain rights of wayleave. However, in the case of one or two large owners who have a considerable home coke trade in the west and south, where such trucks have long journeys, the owners find a portion of their own trucks (or wagons), and are allowed a slight reduction off the mileage rate in consideration of their doing so, as the North-eastern Railway Company do not allow their own coal-wagons to go to places south of their system. It will thus be seen that, where such conditions exist, it is essential to have rapidity in the loading facilities, due regard, of course, being paid to careful handling; otherwise, in times of fog and bad weather, and consequently delay in the arrival of vessels, outlying collieries are often laid back or idle for want of wagons, or else have to resort to the expense of stacking. The collieries under the fourth division do not ship, and those situated outside the terminal of the North-eastern Railway Company have a custom of either handling their own wagons or those belonging to traders, or else they hire from outsiders. The standard charge with traders is 6d. per ton per wagon per journey, plus the mileage rate, such wagon being of not less than 8 tons capacity.

Rolling Stock.—The number of 10-ton wagons required for a colliery working 1,000 tons per day, and lying somewhat contiguous to the loading wharf, may be taken at three hundred. When several such collieries consign their output to a single port for shipment, and when the wagon stock is common to all the pits, a reserve of 20 per cent. in addition to the number required for the daily output will be sufficient; but no hard-and-fast rule can be laid down, as the situation and other factors vary in each case.

The North-eastern Railway Company have, at their North Blyth staithes, tested the utility of wagons of 32 tons capacity, designed by Messrs. Sheffield & Twinberrow, of Newcastle-upon-Tyne. Eighteen such wagons have been in use for some years, and fifty similar cars, of which the capacity has been increased to 40 tons, were more recently put into traffic. These 40-ton wagons are 10 feet in height from the rail, 8 feet in breadth, about 40 feet in length, and have a tare of 16 tons; they are fitted with only two bottom doors, operating horizontally and worked by spur-gearing, with pitch-chain or wire-rope connexions, thus making it possible to open, shut, and regulate them at will. To carry this quantity, four of the ordinary 10-ton wagons are required (with a tare of 25 tons), necessitating the coal being dropped from sixteen bottom doors, which are placed about 1½ feet higher than those on the 40-ton wagons.

A saving of breakage has followed the adoption of the new wagons, as the steel plates form the interior incline from the two ends towards the centre; and, consequently, when the bottom doors are opened, the coal coming away from both ends chocks itself in the centre, and then falls with a steady vertical feed, instead of the rush that follows the dropping of the larger number of bottom doors from a greater height. It is also claimed that, after the first cost of substituting them in place of the smaller wagons, considerable saving will be effected not only by the railway companies, owing to the reduced tare, but also in the cost of maintenance, a point which will more especially affect colliery owners outside Northumberland and Durham, where it is the general custom to own private wagons. The cost in 1900 of building these large wagons to the requirements of the Board of Trade was about £8 per ton of capacity, being somewhat higher

for 32-ton wagons, and lower for the larger sizes, against £8 10s. per ton capacity in the cost of an ordinary 10-ton wagon, the average life of which may be taken as 17 years.* The cost of maintenance (taken from American sources), including the annual cost of painting and repairing the large wagons of the Pressed Steel Car Company, has varied from £2 to £3 each. It would therefore seem that, although the cost of maintenance of the high-capacity wagons might increase with age, it would yet not exceed one-fourth of that of the smaller wagon per unit of capacity. The North-eastern Railway Company have also in traffic at North Blyth a further lot of fifty wagons, each of 40 tons capacity, which have been supplied by the Leeds Forge Company. Each hopper is closed by a pair of inclined hinged doors, worked by the Schœn toggle-joint gear.

Owing to the collieries in the Northumberland and Durham coal-field being (with very few exceptions) old established, with the best part of their life well run, it was found that the general adoption of a wagon of 40 tons capacity would entail too great an expenditure on the part of colliery owners in altering their heapsteads and screens. Therefore a compromise was arrived at, in the early part of the present century, between the colliery owners and the railway companies, for a general adoption of standard wagons of 15 and 20 tons capacity; and at the present time (October, 1908) it may be said that at Tyne Dock and Dunston, at which places the combined shipments amount to from 10,000,000 to 11,000,000 tons per annum, nearly 70 per cent. of the whole is dealt with in wagons of 15 and 20 tons capacity. The majority of collieries in Northumberland have refrained from adopting the larger size of wagon (particularly those with private staithes), as the change not only necessitated alterations to the existing heapsteads at the collieries, but also at their staithe heads. Only one colliery company has adopted the 40-ton standard wagons, and they are run on the North Blyth mineral line of the North-eastern Railway.

In adopting larger wagons, although in many cases a weighbridge will be laid down at the colliery capable of taking the full length of the wagon and registering its gross load, yet owing to the load of the wagon being supported and acting on springs fixed

* "On Capacity of Railway Wagons," by Mr. J. D. Twinberrow, *Proceedings of the Institute of Mechanical Engineers*, 1900, page 557.

to the bogie at each end of the carriage, a weighbridge with the customary short platform, and capable of registering half this weight, is all that is required, for it has been proved that each bogie can be weighed separately in turn, with results as equally accurate as those obtained by placing the wagon on a long weighing-machine.

Inclination of Spouts.—The inclination of the spouts is generally fixed, on an average, at 18 or 19 inches per yard. Rough steam-coal will gravitate on a less gradient, but small, gas, bunkering, and other coal, particularly when in a damp condition, frequently requires assisting over the existing gradient. The inclination of the slopes of the Sheffield & Twinberrow 40-ton wagon is 36 degrees to the horizontal, that is, 26 inches per yard, or, say, a rise of 72 in 100.

Trimming Operations.—The difference in the amount of trimming required on the various types of boats may be summarized as under. According to a statement drawn up by Lloyds a few years ago, and based on statistics compiled between the years 1891-1896, the average life of a steamer may be taken at 16·2 years, and that of a sailing ship at 16·8 years.

It is difficult to estimate the times required to trim the various classes of boats running at the present time, but the writer believes that a general idea may be gleaned from Appendix I., which gives a summary of the trimming rates prevalent on the River Tyne. Gas-coal takes a little less trimming than steam-coal.

However, it is generally admitted that in a double-decked steamer the amount of coal requiring to be trimmed, independent of bunker-coals, is about 30 per cent. of the whole cargo, and in a single-decked boat it is about 25 per cent. These estimates apply to north-country coal; with Welsh coal the trimming is somewhat less, as the holds would not be so full.

The turret build of steamer was designed as a self-trimmer, the breadth of the turret of the earlier types being about 40 per cent. of its maximum breadth; and experience has proved that such boats require only 5 to 10 per cent. of the cargo to be trimmed, and always under 10 per cent. Builders, however, are now designing this type of boat with an increase in the width of the turret to 60 per cent. of the maximum breadth of the vessel, thus not only considerably increasing the general capacity, but at the

same time still further reducing the small amount of trimming required when loading coal by an additional 50 per cent.

It rarely happens that coal must be trimmed under three decks, except in the case of bunker-coal. What are known as vessels built to the three-deck rule generally have only one deck laid, and occasionally two, but seldom three. Very large vessels have sometimes three decks: but this includes the shelter-deck, under which there would be no coals to trim, as there would be plenty of room for them under the next lower deck. There are still a number of small Norwegian cattle-boats of an average capacity of 700 tons, with two or three decks, bringing butter and eggs to the Tyne and loading coal on their return. They are very bad boats to trim, only admitting of teeming 20 or 30 tons before requiring trimmers to descend into the holds.

It will thus be seen that, with the modern type of boat, the rate of rapid shipment depends entirely on the facilities with which the wagons can be handled on the staithe head, if the use of any anti-breakage attachment working off the spouts be ignored.

II.—Arrangement of the Staithe Head.

By the advice of the late Mr. M. Walton Brown, the writer has changed the order of the grouping of his material from that of a geographical into a classified form, in order to present it in the most convenient form for reference. The author does not profess to indite a treatise on the subject, but rather to give a general idea of the methods applicable to the different conditions existing (as regards wagons, etc., and loading facilities) for the shipment of coal; and he has endeavoured to present at least one descriptive in illustration of each of the various forms under such classification. The following list contains examples of the various types of wagons operating under different conditions:—

(1) *High-level or Gravity System.*

(*A*) *Bottom Discharge Wagons with Fixed Shoot.*—(1) North of England; (2) Tyne Dock; (3) Dunston; (4) Derwenthaugh; (5) River Tyne Commission docks, Howdon; (6) Northumberland or Howdon Dock; (7) North-eastern Railway Company's staithes, Howdon; (8) Cramlington Coal Company's staithes, Howdon; (9) Seaton Burn Coal Company's staithes, Howdon; (10) Seaton Delaval Coal Company's staithes, Howdon; (11)

Whitehill Point; (12) Backworth Coal Company's staithes, Whitehill Point; (13) Albert Edward Dock; (14) Harton Coal Company's high-level staithes; all the preceding being situated on the banks of the Tyne: (15) North Blyth; and (16) South Blyth.

(*B*) *End-tip Wagons with Fixed Shoot.*—(1) Wall coal-handling apparatus, Nanaimo, Vancouver Island, British Columbia; (2) Rigg balance tip, West Bank dock, Widnes, Lancashire.

(*C*) *End-tip Wagons with Moving Shoot.*—(1) Seaton Burn Coal Company's staithes, Wallsend-upon-Tyne; (2) Vendin la Viel Wharves, France.

(*D*) *Side-tip Wagons with Fixed Shoot.*—(1) Bethune Collieries Company's wharf, Bassee, France; (2) Lens Collieries Company's wharf, Vendin la Viel, France.

(*E*) *Tipplers* (American practice).—(1) Timothy-Long tippler; (2) Brown hoist-tippler; (3) McMyler tippler.

(*F*) *Belts.*—(1) Robin belt-conveyor system, operating at the Dominion Coal Company's wharf, Louisbourg, Nova Scotia: (2) Victoria Dock, Hull; (3) installation under typical conditions: (4) Dunston and Tyne Dock.

(*G*) *Cranes.*—(*a*) Fixed crane with wagon: (1) Ransome and Rapier arrangement operating at Wallsend-upon-Tyne; (2) Bramley-Moore and Wellington docks, Liverpool. (*b*) Travelling crane with wagon (end-tip): McMyler car-dumper.

(2) *Low-level System with Hoists or Elevator.*

(*A*) *Elevator and Shoot* (end-tip wagon).—(1) Scotland: (*a*) Burntisland dock, No. 2 hoist: (*b*) Burntisland dock, No. 2 hoist, second test; (*c*) Burntisland dock, No. 4 hoist; (*d*) Grangemouth dock; (*e*) Bo'ness dock. (2) North of England: (*a*) Albert and Victoria docks, Hull. (3) South Wales and Monmouthshire: (*a*) Barry dock; (*b*) Port Talbot: (*c*) Penarth; (*d*) Bute docks, Cardiff; (*e*) Newport; (4) Herculaneum dock, Liverpool; (5) Canada branch-dock No. 3, Liverpool; (6) Birkenhead: (7) Partington coal-basin, Manchester ship-canal; (8) Garston docks (Upper Mersey); (9) Poplar docks, London; (10) Whitehill Point (Tyne); (11) Ardrossan (Clyde).

(*B*) *Shoots.*—Difference of form of Welsh shoot compared with that in use in the North of England.

(*C*) *Elevator and Box.—Nil.*

(*D*) *Incline and Shoot.*—(1) American practice.

(*E*) *Cranes.*—(*a*) Fixed cranes with wagons: (1) Queen's dock, Glasgow; (2) Ardrossan (Clyde); (3) Ayr; (4) North-eastern Railway Company's docks, Hull. (*b*) Travelling cranes with wagons: (1) Herculaneum dock, Liverpool; (2) Birkenhead; (3) Harton low (new) staithes (Tyne); (4) Cessnock dock, Glasgow. (*c*) Fixed cranes with boxes, buckets, or skips: *nil*. (*d*) Travelling cranes with boxes, buckets, or skips: Roath and Bute docks, Cardiff. (See Lewis-Hunter anti-breakage crane, described under Anti-breakage Appliances, page 715.)

III.—Aerial Ropeway and Hopper and Shoot.

Gowrie and Blockhouse Colliery Company's wharf, Port Morien, Cape Breton, Nova Scotia.

IV.—Anti-breakage Appliances.

North of England: (*a*) North country: (*b*) Wrightson coal-shipper (1) Cramlington Coal Company's staith (Tyne), (2) Alexandra dock, Grimsby: (*c*) box-drop appliance; (*d*) telescope arrangement: (*e*) Handcock appliance; (*f*) Ballan & Morison appliance: (*g*) Rigg appliance (1) doors released from deck by cord, (2) doors released by contact, (3) continuous chain of buckets: (*h*) South Wales (1) ordinary anti-breakage box, (2) Thomas-Batchelor box, (3) sundry other boxes in general use, (4) Lewis-Hunter patent crane.

V.—Floating Elevators: Rigg Arrangement.

VI.—Conclusion.

VII.—Appendices.

I.—Trimming rates at Tyne Dock.

II.—Description of Merrick conveyor weightometer.

It will be seen from the above that, with only two exceptions, the whole of the working staithes on the Tyne come under the high-level system with bottom discharge and fixed shoots: whereas in South Wales and elsewhere throughout this country the general principle seems to be to lay down some sort of elevator or hoist, presumably largely owing to the fact that such appliances are able to handle other merchandise than coal.

II.—Arrangement of the Staithe Head.

(1) High-level or Gravity System.

(A) *Bottom-discharge Wagon with Fixed Shoot.*

(1) *North of England Arrangements.*—In this country, the various staithes are all laid out on the switching-off principle, and the trucks or wagons are handled either by gravitation or by some other similar means. The bulk of the coal shipped on the south side of the Tyne is gas-coal, whilst steam- and house-coals are solely shipped on the north side, and consequently much greater precautions are needed to minimize breakage in the latter case.

On the southern bank of the Tyne, the North-eastern Railway Company are the greatest loaders, as they own the staithes both at Tyne Dock and at Dunston.

(2) *Tyne Dock.*—Tyne Dock occupies 50 acres of water-area, and ranks as one of the largest coal-exporting docks in the world. The total shipment of coal and coke for 1901 exceeded 7,000,000 tons; and their record day's shipment, on February 7th, 1898, was 34,930 tons. It amounted to 3,500,000 tons for the second half of 1907. This quantity was shipped at four jetties, running parallel into the dock at the southern end. Each jetty is from 500 to 550 feet long, and there is berthing accommodation for sixteen vessels concurrently.*

Each jetty is approached by a group of storage sidings, or, as it is termed locally, a "field," and each "field" by two reception lines connected with the main lines. From the reception lines, where the locomotive is liberated, the wagons are shunted by gravity into the "fields"; and subsequently, as required, the same force brings them on to the jetties. In these fields and sidings there is storage accommodation for about 17,000 tons of coal (each truck holding $10\frac{1}{2}$ tons), or more than half a day's average shipment. This quantity can, however, be very considerably increased under circumstances of pressure.

Each jetty has six lines, from which the spouts are fed. The truck gravitates down a gradient of 1 in 100, and then, meeting a short distance of line at 1 in 20, receives the necessary impetus to

* *Proceedings of the Institution of Mechanical Engineers*, 1900, plates lxxxi. to lxxxiii.

carry it up the rising gradient of the jetty (1 in 100) to the particular shoot at which it has to be discharged, so that, at the actual shipping-point the truck stands on a falling gradient in the reverse direction, and (after being emptied) runs by gravity into one of the sidings for empty wagons, where the locomotive is gathering its load for its return to the collieries.

No. 1 jetty has four spouts on each side, and Nos. 2, 3, and 4 jetties each have five spouts on each side. The spouts are, as a rule, spaced 100 feet apart. It is found that in only about 20 per cent. of the total vessels loaded can two spouts be utilized concurrently. The shoots, 26 feet long, can be placed at any one of the three connexions with the hopper, giving 3 degrees of height for loading into vessels, and they vary in depth from hatchway to water-level.

In the actual process of shipment, ten or even fifteen trucks are run on to the teeming line, and after being brought to a stand above the hoppers, they are rapidly discharged and switched away to the empty siding; and so soon as the last one has passed the hopper, a second set of trucks follows in, the spout in this way being fed as rapidly as the steamer can receive her cargo.

The following cases of quick shipment of cargo and bunkers may be mentioned:—In March, 1882, the screw steamer "Spero," loaded 1,044 tons in 2 hours 10 minutes, or at the rate of 480 tons per hour; in June, 1895, the screw-steamer "Medway," 1,295 tons in 2 hours 30 minutes, or 525 tons per hour; in November, 1895, the screw-steamer "Linhope," 1,750 tons in 2 hours 55 minutes, or 600 tons per hour; in March, 1898, the screw-steamer "North Dene," 1,800 tons in 3 hours 50 minutes, or 450 tons per hour; and in June, 1900, the screw-steamer "Sunningdale," 2,400 tons of cargo in 4 hours, or 600 tons per hour.

These actual cases shew that a ship's cargo is regularly loaded at the rate of 500 tons per hour, including the various stoppages incidental to shipping, such as moving vessels to the various spouts, etc.

Experiments made recently, in order to compare roughly the rate of shipment by means of jetties constructed similarly to these with the method of shipping from a hydraulic hoist, proved that a run of ten trucks (each containing 10 tons) could be shipped consecutively in $4\frac{3}{4}$ minutes, or at the rate of 1,260 tons per hour; whilst ten trucks, each one being taken from the adjoining line

separately on to the hopper and emptied before the next was brought to the shipping point, occupied $11\frac{3}{4}$ minutes in shipping, or at the rate of 510 tons per hour (although no time was lost by this method). This shows a great difference altogether in favour of the jetty for quick shipment, the only disadvantage being that in the case of very large boats the jetty system limits the height, whereas the hydraulic lift gives facilities for any boat at a moderate rate of shipment, and is particularly suitable for bunkering large vessels.

With the object of overcoming this difficulty, four electrically-driven belt-conveyors have been put to work within the past five years, with such satisfactory results that others are now being erected. These conveyors enable vessels of a considerable height to be loaded or bunkered, and are capable of delivering coal with the belt at a considerable angle above the horizontal.

(3) *Dunston Staithes.*—The North-eastern Railway Company erected staithes and deepened the Tyne at Dunston, with a view of making the staithes auxiliary to those of Tyne Dock, in dealing with the increasing tonnage from the Annfield Plain and West Durham collieries. The total tonnage shipped from these staithes for the second half of 1907 amounted to 1,640,000 tons, the record day's shipment being 15,919 tons. The whole length of the structure is about 1,709 feet, and is brought out into the river with a curve. It was erected in two portions, the outside length being already finished and working in 1901, whilst the erection of the inner portion was completed and opened in 1903. There are six loading berths (three being on each side of the structure), which are placed about 263 feet apart, and contain two spouts to each berth, the spouts being placed about $87\frac{1}{2}$ feet apart.

Each side is laid out with four tracks: the three inner ones being the full way, the fourth and outside one the empty and outgoing one; and each track is laid out with a rise to the far end of 1 in 96. The trucks are pushed along by locomotives, and on the inbye side of the respective loading-berth; they are then switched off on to the outgoing line by gravitation in batches of 10 to 20, and run over the spout, where they are teemed consecutively and, when possible, simultaneously down each of the two spouts, there being standage space for four full trucks in between each spout.

The following may be described as typical cases of the length of time occupied in loading steamers of what are known as the ordinary collier class:—The screw-steamer "Lambeth," an easy trimmer, took in 113 trucks of 10½ tons each in 1 hour 50 minutes, or 664 tons per hour: as two shoots were working into the vessel during the time of loading, one shoot loaded 332 tons per hour. The actual time of teeming coal into this boat was 1 hour 20 minutes, the balance of the time including delays in taking off hatches and getting the boat ready and shifting: that is, for one shoot, the rate was 445 tons per hour. The screw-steamer "Harborne," an ordinary trimmer, took in 160 trucks of 10½ tons each in 5 hours, or at the rate of 336 tons per hour. The contents of forty trucks can be teemed down one spout per hour: and the length of time occupied in changing the truck and emptying into the shoot, under ordinary conditions, takes 1 minute: even under pressure it is difficult for this time to be reduced.

These staithes are now being provided with three steel belt-conveyors similar to the one at South Blyth, hereinafter described, each capable of loading a vessel at the rate of 500 tons per hour, and working at an elevation of 40 degrees above the horizontal.

The North-eastern Railway Company are contemplating at the present time (December, 1908) the erection of additional staithes a little farther up the river at Derwenthaugh, in order to ease the pressure of operations at their Dunston staithes.

(4) *Derwenthaugh.*—The Consett Iron Company, Limited, have recently erected new staithes in connexion with their Garesfield colliery. The tracks to and from the main sidings are laid in the form of a triangle, the river frontage forming its base. There are two loading spouts, situated about 100 feet apart: but it is seldom that the two can be utilized at the same time in the loading of a vessel, and the low spout has an independent road for most of the distance. Formerly only 4-ton wagons were in use, but 10½-ton trucks are now alone used. Owing to the limited length of the river frontage, three parallel tracks are laid, switching into one some 40 feet above the second spout, thus allowing standage for seventeen loaded trucks, which are shoved up one of these roads by locomotives: thence they gravitate to their teeming point, and onward to a turntable, where they are twisted off at

right-angles, and gravitate down the empty track of 1 in 71 into the empty bay. This turntable is 14 feet in diameter, and the rails on it are laid at the same gradient as the track approaching and leaving it: limited space necessitated its laying down, otherwise the switchback arrangement direct from the spout on to the empty track would have been adopted. The teeming track was laid out with a gradient of 1 in 76·37 as far as No. 1 spout, then 1 in 186·89 between the two spouts, in order that each might be of a uniform height, and 1 in 66 between No. 2 spout and the turntable, whence they gravitate at 1 in 76 into the empty bay. The turntable is worked by hand, and can be operated by one man; but for expedition two men are stationed there. These men also run the empty wagons from the spout to the turntable, put up the bottom-boards, and start the wagons down the empty track. The time actually occupied in teeming a truck at the spout is 45 seconds, and the additional handling before it clears the turntable occupies another minute. The average tonnage dealt with at one spout per hour is 450 tons, and the quickest rate of loading and despatch was accomplished with the screw-steamer "Harborne," a self-trimmer, which loaded 1,600 tons in $4\frac{3}{4}$ hours.

(5) *River Tyne Commission.*—On the north side of the Tyne, the principal coal-loading centres are situated at the Northumberland or Howdon dock, Whitehill Point, and the Albert Edward dock, all of them belonging to the River Tyne Commission. The total tonnage of coal and coke shipped there in 1901 amounted to 3,293,002 tons, the tonnage having increased to 3,714,648 tons in 1907. At these centres, with the exception of those belonging to the North-eastern Railway Company and others retained and fitted up by the River Tyne Commission, many of the colliery companies own their own staithes, and several colliery companies also own private staithes higher up the Tyne.

(6) *Northumberland or Howdon Dock.*—This dock covers a water-area of 55 acres, and contains eleven different staithes, which with the exception of five belonging to the North-eastern Railway Company, are owned or leased by colliery companies. The tonnage of coal and coke shipped here in 1901 amounted to 2,004,320 tons; the total tonnage shipped during 1907 amounted to 1,976,467 tons, of which 1,016,649 tons was handled during the latter half. Owing to the rising nature of the ground away

from the water-front, with the exception of one staithe belonging to the Seaton Delaval Coal Company, and presently described, each of these staithes are supplied by self-acting inclines from the feeding sidings, which have been placed as near as the contour of the ground admitted. These feeding sidings are supplied direct from the collieries by locomotives.

(7) *The North-eastern Railway Company.*—This Company owns five staithes, three being fitted with three spouts on each side, and the other two are fitted with three spouts on one side. The inclines, dipping approximately 1½ inches per yard and averaging about 100 feet in length, are laid with double track. Only 10-ton trucks are employed (supplemented more recently by some of 15 tons capacity), and they are braked down by a drum and rope in sets of two wagons, the rate being about 40 trucks, or 400 tons per hour, in fine weather; in frosty or snowy weather, only 60 per cent. of this quantity can be handled. Two men are employed at the top of each incline, one being at the brake, while the other couples and uncouples the runs. At each end of the wire rope, there is about 20 feet of small chain attached, which enables the empty runs to be disconnected without any coiling of the rope on the ground. On the staithe, two teemers and one boy at the trap are employed. The arrangement of the spouts is exactly similar to that adopted for those erected at Tyne Dock.

(8) *Cramlington Coal Company.*—The Cramlington Coal Company's staithe is fed on the same principle as the above, but 4-ton wagons as well as 10-ton trucks are in use. The length of the incline is 700 feet, with a fall of 1¼ inches per yard. The time occupied in running and teeming a set of three wagons is 2 minutes 24 seconds. On self-acting inclines, it is interesting to note the difference of time occupied in the handling of 10-ton trucks as compared with 4-ton wagons. The Wrightson anti-breakage coal-shipper is in operation at one of the staithes belonging to this company, and is described later under anti-breakage appliances.*

(9) *Seaton Burn Coal Company.*—At the Seaton Burn colliery staithe, the staithe sidings are ¾ mile away from the loading-jetty, and this incline is worked by a standing engine placed at the top. The run of nine or ten wagons takes 10 minutes

* See page 227.

from being pulled off the empty road at the jetty until a full run is landed on to the jetty. Although this is one of the few inclines on the Tyne that are not worked by self-acting means, yet this system possesses the advantage over the other roads of never being hindered in frosty and wintry weather from starting the empty run of wagons from the jetty.

The jetty is arranged for end-on loading, and is fitted with three spouts, the middle one being most frequently used. It enables two wagons to be run over the switches at a time, and then teemed consecutively, and switched on to the empty siding. It takes 3 minutes to teem and change the wagons. At the best, 130 to 150 tons per hour can be handled by this arrangement, under ordinary conditions. It usually takes 10 hours to teem 700 tons, although with a good class of boat the quantity can be handled in 7 hours.

The spout has an exceptionally large taper, its width being considerably reduced towards its bottom end, and two half-doors, which can be opened and shut at will, are fixed in the spout 4 feet from its end. The spout can also be shortened by 3 feet at will, the last 3 feet (called a "butterfly," and worked by additional gearing on the windlass) tilting up, thus affording teeming operations from its extreme end, or at the near side of the butterfly, as required. This contrivance can in this way keep two sets of trimmers at work: it reduces or avoids the listing of the boats, and consequently ensures the better mixing of the coals. The spout will hold the contents of two wagons, or 8 tons, and when teeming 10 to 12 cwts. of coal are always left in it, thus hindering the coal from each succeeding teem from falling against the ironwork: and, as the doors prevent it from getting away, it is claimed that a considerable saving in breakage is thus effected.

(10) *Seaton Delaval Coal Company.*—The Seaton Delaval Coal Company own one of the finest and most modern laid-out staithes on the north side of the Tyne (Figs. 12 to 18, Plate XXX.), erected in 1876.

After considerable excavation, both for deep water prior to the driving of the piles towards the further end of the staithes, and on the land in order to work the staithes by a system of gravitation, owing to their railway going round the contour of the district, the Company's locomotives are enabled to bring the

full wagons down from the main siding direct to the inshore end of the woodwork of the staithe. The former are then uncoupled, and switched off down into the bay to which the empty wagons gravitate. The full wagons are gravitated in sets down to the spouts, the track being laid at a series of grades (Figs. 17 and 18, Plate XXX.), starting with a dip of 1 in 53 for the first 97 feet, and then 1 in 24 for the next 91 feet, the impetus of which (unless the set be switched off to one of the nearer spouts) can send it up a rise of 1 in 95 to the far end of the gangway, a distance of 269 feet. After being switched and teemed, on their return journey the wagons gravitate down the 1 in 95 gradient, which is carried uniformly past the full road switches down into the empty bay, whence they are drawn out by locomotives.

From three to twelve wagons of 4 tons comprise a run, according to whether the far or inshore spouts are in operation, and, under these conditions, 500 tons or 125 wagons can be handled per hour.

The staithe (Figs. 12 to 16, Plate XXX.) is fitted with four spouts on the eastern side, and three on the western side, and one end-spout, the hopper of which by means of gearing can be changed to work into the far side-spout as required. There are four teeming heights at each spout. There is a capacity of 12 tons in each hopper, thus allowing 2 or 3 tons to be always left in to lessen breakages; and as each spout is fixed with a swinging door at its end, and can also be raised nearly level, the exit-speed of the coal into the boat can be regulated.

(11) *Whitehill Point.*—The tonnage shipped at these staithes during 1907 amounted to 1,293,387 tons, of which 690,097 tons was shipped during the latter six months. There are four staithes in operation at this centre, two of which are worked by the River Tyne Commission and the other two are operated by the Backworth Coal Company. Each of the two staithes operated by the River Tyne Commission is fitted with four spouts placed side by side; and, in the case of certain regular traders built for the purpose, all four spouts have been in use at the same time. At two of the spouts on each staithe (a second hoist has recently been erected, which illustrates the success of the first one laid down) Armstrong hydraulic lifts have been installed.

The loaded truck (10 tons) is hauled (by means of a hempen rope worked round a vertical sheave turned by hydraulic power)

on to the platform of the lift, which is then raised (at the rate of 2 feet per second) to the height of the telescopic spouts (which is regulated by the height of the tide and the cargo), teemed, and then lowered on to the staithe-level again. By means of another hempen rope the wagon is drawn back and switched on to the empty road, a distance of 36 feet from the lift-platform, before clearing the fouling point. In the interval of teeming and switching one truck, the other rope is attached to the next wagon, so that it is drawn forward on to the lift without loss of time.

It is claimed that forty trucks, or 400 tons per hour, can be handled by this system, that is, as fast as the rate at any one of the three adjoining ordinary spouts, where, owing to the existing conditions, the fouling crossings cannot be situated as near up to the spouts.

(12) *Backworth Coal Company.*—The Backworth and West Cramlington Coal Company have two staithes, at one of which the old-fashioned spout system is in operation. The trucks are worked on and off them by the gravitation system. Both 10-ton trucks and 4-ton wagons are in use. When working at the end shoot, only one wagon is run down at a time; but, when the second or lower one is in use, two wagons are run down at a time, and teemed consecutively. In the case of trucks, the four bottom doors are opened at once.

Under these conditions, in good weather 400 tons can be handled per hour; and in snowy weather about 300 tons per hour. The following are typical cases of loading:—The screw steamer "Kingmoor," a boat with seven beams and with all the trimmers in one hatch, loaded 1,030 tons of cargo and 40 tons of bunkers (a total of 1,070 tons) in $3\frac{1}{2}$ hours; and the screw steamer, "Harbottle," a self-trimmer, took in 2,000 tons of cargo and 40 tons of bunkers (a total of 2,040 tons) in $6\frac{1}{2}$ hours.

At the other staithe, up to a few years ago, there was a coal-shipping drop,* which was designed to remedy the difficulty found at other coal-drops in holding ships in position by warps, particularly when loading in rivers or tidal basins, and in adapting the drop system to lofty staithes. Here the gradient of the tracks is such that the trucks can be worked on the gravity system. In fine weather about 42 wagons (or 150 tons per hour) may be handled, and about 100 tons in snowy weather.

* *Trans. Inst. M.E.*, 1898, vol. xv., page 79.

This system is, however, unsuitable for wagons of more than 4 tons carrying capacity. For larger wagons, a crane worked by steam or water-power is better adapted, and the effect of these two methods is identical. Most modern steamers are fitted with hatchways and loose cross-beams, which will admit of 10½-ton trucks being lowered into the hold for the prevention of coal-breakage. After a cone of sufficient size has been formed on the bottom of the ship, the strengthening beams across the hatchway can be replaced and the loading completed.

(13) *Albert Edward Dock.*—The Albert Edward Dock covers a water-area of 24 acres, and contains only one staithe, which belongs to the River Tyne Commission. The shipment of coal and coke in 1901 amounted to 446,242 tons; whilst in 1907 it had decreased to 444,794 tons, of which 194,433 tons were shipped during the latter six months. This staithe was erected at a later date than the one owned by the Seaton Delaval Coal Company at Northumberland dock: but it is laid out after the same principle, the difference being that two full-wagon tracks are brought down the centre to the far end of the gangway, the loaded trucks being then switched off to either side and on to one of two empty-wagon tracks, whence, after teeming at their respective spouts on the return journey, they gravitate into one of two empty bays, situated at each side of the structure. There are two teeming tracks: at high-water the outside empty track is used, and at other times those on the inner track. Only 10-ton trucks are used, and they are gravitated down in sets of two and three.

This staithe has four spouts on its eastern and five on its western side, fixed at irregular distances apart, to suit various classes of boats. Each spout has four teeming heights and a teeming hole for each, but there is only capacity for about 8 tons of coal in the hopper; consequently, there is only open space enough to teem half a wagon at once, and thus time is lost in bringing the truck forward before the second half can be teemed.

If the coal be good, it is possible to teem one truck every minute; but on an average it takes 2 minutes per truck, which equals 300 tons per hour. The company claim to have shipped with a clear teem from 600 to 700 tons per hour. The following may be taken as typical of the time occupied in loading at the spouts:—The "Longships," 904 tons of bunker-coals in 4 hours; the "Breckfield," 688 tons of bunker-coals in 5 hours; the

"Cameric," 482 tons of cargo and 683 tons of bunker-coals (a total of 1,165 tons) in 9½ hours; and the "Gemini," 40 tons of bunker-coals and 1,140 tons of cargo (a total of 1,180 tons) in 4 hours.

(14) *Harton High Staithes.*—In addition to the staithes described on page 215 under "Cranes," the Harton Coal Company, Limited, also own and operate the staithes shown in Fig. 30, which may be taken as a typical illustration of the old form of box-drop staithe so prevalent on the Tyne in the middle of the eighteenth century. This staithe, which is used principally for loading small steamers and sailing vessels, comprises three drops and one shoot, the latter being principally used for loading small craft (barges) with limestone. The approach to the staithe is at right-angles to the line of quay, with the exception of one drop, which is situated in a direct line with such approach; and at this drop the distance between the points for shunting the wagon, after teeming, on to the empty line and the cradle of the drop is about 27 feet.

Only 4-ton wagons can be dealt with, and at this drop thirty-five to forty wagons are teemed per hour (equal to 160 tons maximum) with a light steamer of, say, 500 tons and upwards, and with hatches 20 to 25 feet long; but, after the coals have been run up to the combings, it is impossible to handle more than twenty-five wagons, equal to 100 tons per hour.

With a sailing vessel of, say, 300 tons, the hatches of which only average 6 to 8 feet in length, only fifteen wagons can be handled, equal to 60 tons per hour. For the other two drops the lines of rails (two full and one empty) are laid parallel to the quay, and turntables are placed in order to turn the wagons off on to one or other of the short jetties, the distance between the turntable and the cradle thereon being 27 feet. Here it is not possible to handle more than thirteen to fifteen wagons per hour, equal to 60 tons maximum.

There are two or three private staithes on the south side of the Tyne, owned and operated by independent colliery companies, where the old 1½-chaldron or 4-ton wagon is in use; but typical cases under these conditions will be found described with the staithes in operation on the north side of the Tyne.*

* See pages 149, 152, and 162.

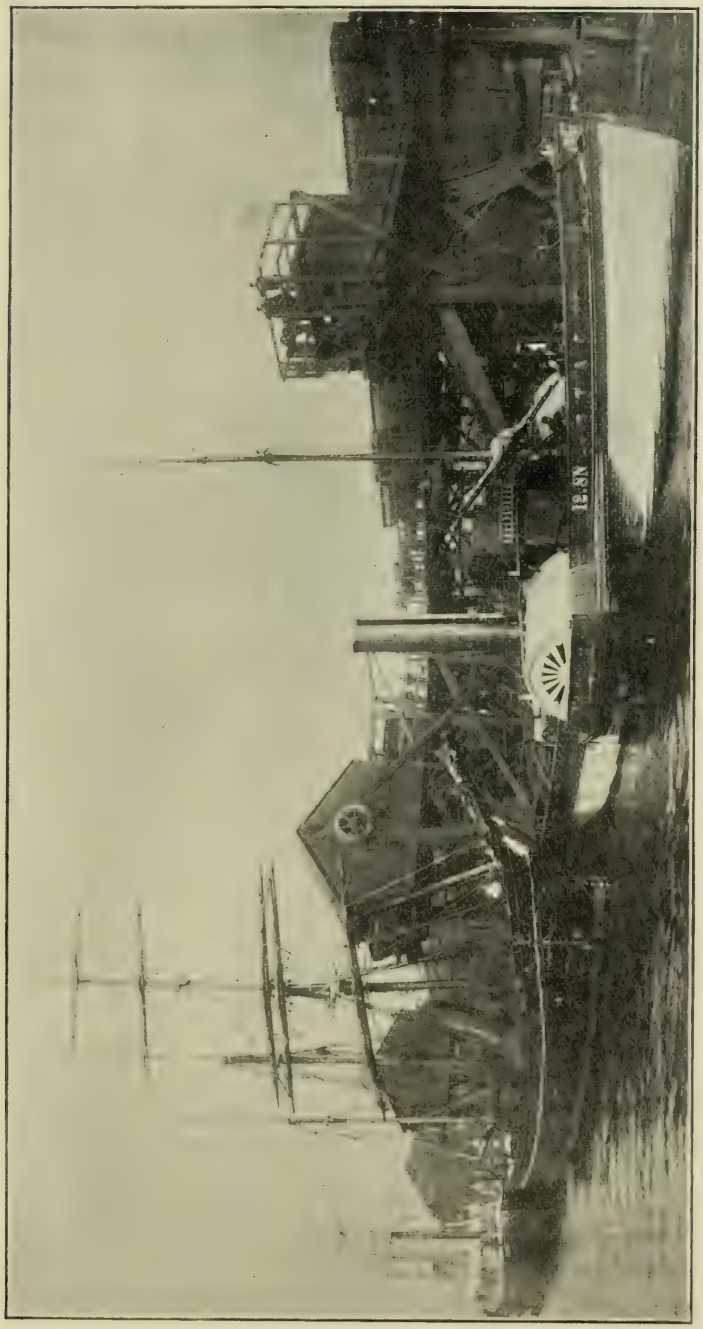


FIG. 30.—TYPICAL OLD NORTH OF ENGLAND COAL-SHIPPING STAITHE: HARTON COAL COMPANY'S HIGH STAITHE, SOUTH SHIELDS (TYNE).

(15) *North Blyth.*—The staithes belonging to the North-eastern Railway Company have been laid out upon somewhat the same principle as their Tyne Dock staithes, previously described. The full track rises at 1 in 90 towards the far end, and the empty track falls at 1 in 60, the two, after joining together, passing underneath the full roads near the shore end. The height varies from 44 to 48 feet, and there are four sets of spouts placed from 350 to 360 feet apart, each set consisting of two teeming spouts placed 90 feet apart.

The loaded trucks are shoved by locomotives to the far end of each track, switched off, and gravitated down to the respective spout in use after teeming, and then gravitate away into the empty bay. With 10-ton trucks, 700 tons per hour can be shipped at one spout.

(16) *South Blyth.*—The total shipment of coal and coke from the south-side staithes at this port for the second half of 1907 amounted to 660,000 tons, the record day's shipment being 6,476 tons. These staithes are also the property of the North-eastern Railway Company, and may be considered as being the finest and most perfect of any that they own and operate. The roads for the full wagons are laid out on a gradient of 1 in 80 at the approach to the spouts, the wagons, after teeming operations have been performed, running on light as far as the switches, and then gravitating back-over into empty siding bays, whence they are caught hold of by the locomotive. These staithes are laid out in a manner similar to those on the north side of the harbour and elsewhere on the company's system, with, however, the addition of one electrically-driven coaling appliance of the steel-belt type, capable of delivering coal to vessels which are too high for the ordinary spouts.* This appliance is capable of delivering coal into a vessel at a point 43 feet above the high-water mark of ordinary spring tides, the rate of delivery being 400 tons per hour. The harbour is also being dredged so that facilities may be given for bunkering vessels of large size at any state of the tide.

(B) End-tip Wagon with Fixed Shoot.

(1) *Wall Coal-handling Apparatus.*—During the writer's journey through Vancouver Island in 1900, he was surprised at

* See "Belts," page 176.

the speedy coal-loading facilities in operation in that country. The necessity for providing rapid loading and quick despatch for a fleet of steam colliers of from 4,000 to 6,000 tons burthen each stimulated Mr. Samuel M. Robins, the Superintendent of the New Vancouver Coal Company, to grapple with the difficulties involved in an old system of end-on jetties, by heightening and increasing the approaches, and erecting bunkers of large capacity near by; and, in 1899, by adopting the mechanical appliances of Mr. W. H. Wall. Should there be a shortage of wagons, or should the pits' output not be able to meet existing requirements, the wagons are loaded from under the bunker-shoots, and are then run along and raised by locomotive power to the level of the jetty track.

The principle of this invention (Figs. 1 and 2, plate XXIX.) depends on four independent sets of cylinders, each placed to work their own respective attachments, as follows:—Two separate tracks are laid to the far end of each jetty, where there is a traversing table, *H*, operated by a steam-cylinder, *C*, which receives the loaded wagons singly, and thus transfers them across to the adjoining track. This arrangement effects the teeming of the wagons in a continuous run on the outgoing or empty track, instead of the incoming one, and also effects a saving of time by dispensing with the switching arrangements so prevalent in England.

The loaded wagons are run forward on to the staithe or jetty (as far as the hereinafter-described tilting-dog arrangement) by a locomotive, which is then uncoupled and goes off with the then standing empty wagons; but, by the action of a cylinder, *A* (Figs. 1 and 2, Plate XXIX.), fixed at a lower level and midway between the two rails of this tract, and working a piston-rod and cross-head, *W* (running in guides), which carries a tilting-dog, to catch hold of the axle and bring forward the loaded wagon, the foremost wagons (which have passed the dog and been uncoupled) are at the same time forced forward, and the front one is placed on to the traversing-table. After the cylinder, *C* (Figs. 1 and 3, Plate XXIX.), has traversed the table across to the outgoing track, the action of a third cylinder, *D* (Figs. 1 and 4, Plate XXIX.), fixed to the framework at the end of the jetty, sends the wagon forward on to the outgoing track. The table is then shot back, and receives the next wagon. Another arrangement similar to

that shown at *A* (only, instead of a large-sized single cylinder placed underneath and between the track, two smaller cylinders, *BB* (Figs. 1 and 4, Plate XXIX.), are placed at the outside of each rail (owing to the open space necessary for teeming into the highest of the series of spouts) and conveys the full wagon to its teeming-position.

The bottom door of the wagon, which is made in one piece, is then shot open by hand, and the contents are teemed down the spout, the bottom door of the wagon acting as the upper portion of the spout during the teeming operation. The wagon then passes over a light inclined framework arrangement, *T*, centred and working on a pivot at the point, t^1 (Figs. 1 and 4, Plate XXIX.), and having a chain-and-weight attachment at its lower end, in order to bring it back into position, its action raising the door as the wagon passes over it, which is then snecked by hand, and the wagon is coupled to the empty run.

Figs. 6 to 11 (Plate XXIX.) shows an enlarged section of the cylinder, cross-head and tilting-dog attachment. Each cylinder is fitted with a lever and valves for controlling the direction of its respective piston; and, as the four levers are placed side by side, they can thus be consecutively manipulated by one man, the steam being carried from the workshop boilers, a distance of about 600 feet.

A trip consists of twenty wagons, each carrying 6 tons, and their discharge has been often accomplished in 8 to 8½ minutes, equivalent to 960 or 1,000 tons per hour. It is a regular occurrence to teem 750 tons per hour down one spout, and this quantity could no doubt be increased if larger wagons or trucks were in use. At the double staithes (Fig. 31), they are easily and regularly teeming 1,500 tons in the hour, and a fair-sized boat may be loaded and despatched in 6 hours or less, including plenty of time for trimming the hatches. As an illustration, on July 7th, 1899, the screw-steamer "Titania," a self-trimmer, was loaded with 6,000 tons in 10 hours 35 minutes, although a delay of 30 minutes occurred, owing to an accident to one of the loaded wagons.

In the Nanaimo plant, the cylinders working the tilting-dog arrangement on the full road are 6 inches in diameter, the pair working the arrangement on the empty way are 3 inches in diameter, and the little cylinder which gives the wagon impetus and sends it forward off the traversing table has a diameter of

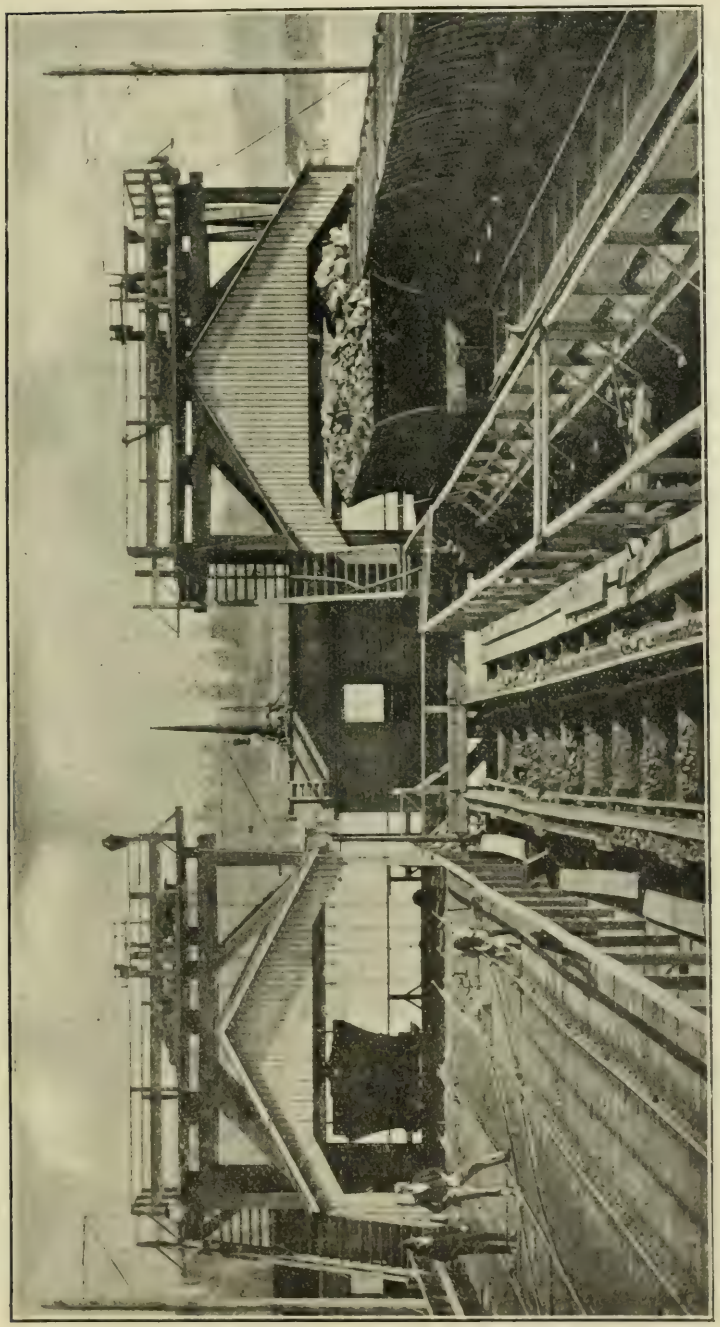


FIG. 31.—WALL COAL-HANDLING APPARATUS, NEW VANCOUVER COAL COMPANY'S WHARF, NANAIMO, VANCOUVER ISLAND: GENERAL VIEW OF THE RE-MODELLED STAITHE HEADS.

2 inches. Special valves have been designed to work these cylinders (Fig. 5, Plate XXIX.), which take the place of the ordinary slide-valve in common use on most engines for regulating the admission and release of steam in the cylinder.

Pipes connect to either end of the valve, with ports or branches at either end of the cylinder, and these pipes take the place of the usual ports or steam-passages in a steam-engine cylinder. The action of the valve admits live steam to one end, whilst the other is open to the atmosphere for exhaust steam, as may be seen from the diagram. The valve is of piston form, and is of constant equilibrium; for slow-working piston speed, as is always the case with steam rams or pistons, it can be placed at a distance from the cylinder under direct control of the operator, who thus has the four or five valves actuating the various rams or pistons concentrated in one spot, side by side on the working platform or base from which he controls the whole operation, and moves or stops the loaded wagons at will in their progress forward. The valve, being controlled by hand, is a combined steam regulator and a reversing valve, and the operator can at will start, stop, or reverse the steam-ram or piston by a touch of his hand.

The valve, piston, and rod are fitted and packed in the usual way; and a lever to each valve is arranged as may be desired for handy manipulation, a special feature being the small space occupied by each valve.

After seeing and comparing the various systems of loading at present in operation on the Tyne with those where the Wall method is practised, the writer thinks that in some ways this invention offers in certain directions advantages which may be summarized as follows:—Although the invention was originally adopted to meet the difficulties encountered with end-on jetties, yet the system of working the trucks forward by the cylinder is an improvement on starting them forward by hand, where the gravitation system has been laid down and its slowness is enhanced by faulty or insufficient lubrication, especially in wintry or frosty weather. The levers working a series of cylinders could all be placed side by side, and thus manipulated by one man; whereas at Tyne Dock, Blyth, and Dunston, although the usual complement of hands employed during loading operations is five men on the staithe head and fifteen trimmers in the

ship, yet the rapid loading is acquired through what is termed "doubling-up," that is, placing ten men on the staithe-head and, say, thirty trimmers or more in the ship. The Wall method requires only three men on the staithe-head, thus effecting a considerable saving in wages, and at the same time enables a constant regular quantity to be handled, depending of course on the class of vessel handled.

From experience in this country, it has been found that the greatest speed facilities can be acquired by laying a staithe out and constructing the spouts at the side, the time gained in this way being considerably in excess over that where the end-on spout is used; but this either entails a good deal of dredging, or, as in the case of the Dunston staithes, the necessity of a large amount of river frontage.

If sufficient standage for a set of loaded wagons can be made at the entrance to the staithe-head, until another run can be brought up, there is no doubt that (with the aid of the Wall apparatus) after what has been accomplished on Vancouver Island, the ordinary end-on jetty can be made so that the same (if not a greater) tonnage can be handled than is at present being handled anywhere in this country at much more elaborately laid-out places, without the expense entailed in their construction.

(2) *Rigg Balance Tip.*—The Rigg balance tip (Fig. 32) is another system of loading coal under control of a brake; and, by utilizing gravity, when available, in preference to hydraulic or other power, it has been applied with success to the tipping of end-door, narrow-gauge (4 feet 8½ inches) railway-trucks, an example doing good work being now at work at the West Bank dock, near Widnes, Lancashire. The machine has been fully described in *The Engineer*,* and consists of an oscillating platform strongly constructed of wrought-iron, and so balanced that all trucks of medium length, when placed in the machine, tip it forward and put it into action, under the control of its brake. The projecting spout or shoot parallel to the floor of the wagon conveys the coal into the hatch, thus not only avoiding the intervention of a separate shoot, but materially reducing the breakage which occurs in the passage of coal from a truck when otherwise tipped above the ordinary adjustable shoots. The machine is used principally for loading small coasting vessels,

* 1885, vol. lx., page 2.

and its capacity is necessarily limited to the rate at which the cargo loaded can be trimmed in the hold, otherwise its regular performance of 1,000 tons per day of 10 hours could easily be increased. To give increased facility for changing hatchways, the projecting spout is so balanced and arranged that it can be raised or lowered to any inclination.

(*C*) *End-tip Wagons with Moving Shoot.*

(1) *Wallsend Staithes.*—There are two sets of staithes situated here, one operated by the Seaton Burn Coal Company, and the other recently reconstructed and belonging to the historical Wallsend colliery, lately re-opened.

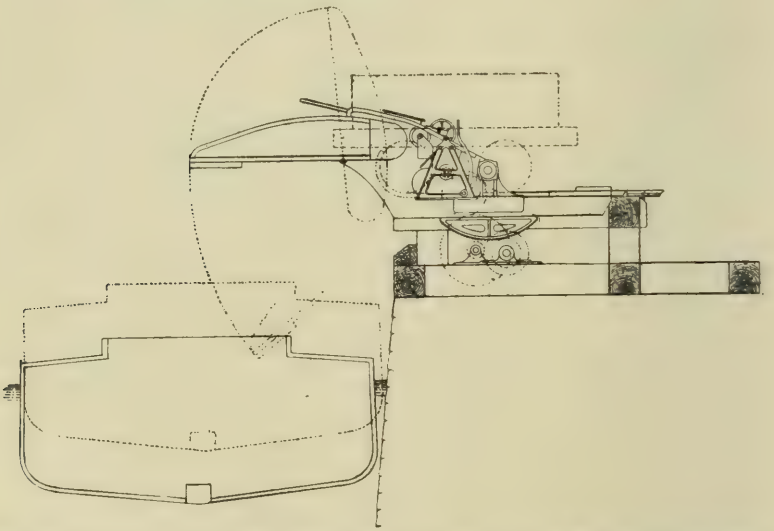


Fig. 32.—Rigg Balance Tip, at West Bank Dock, near Widnes, Lancashire.

The Seaton Burn staithes, already described by Mr. E. W. Crone,* consists of a range of three fixed spouts, four tiers in each, at a distance of 45 feet apart, sloping at an angle of 40 degrees. A swinging spout reaches from the front of the fixed spouts to the centre of the hatchway of the vessel, and is raised or lowered by winches as the tide rises and falls. Formerly, the vessels were loaded through the swinging spout direct into the hold, thus causing considerable breakage in the coal, varying with the depth of hold.

* *Trans. Inst. M.E.*, 1898, vol. xv., page 72.

To avoid this, a telescopic spout was designed, consisting of three sections, which may be of any length.* The top part of the section is placed immediately under the outer end of the swinging spout, to which it is secured by light chains to keep it in position for loading. The telescope is then run down into the hold of the vessel, by lowering the main chain of the crane. The coals are teemed in the usual way, until the spouts are filled up to the wagon. The lowest section of the spout is then lifted by the crane sufficiently to allow the coals to flow gently into the vessel's hold. In loading, the craneman watches the coal in the swinging spout, and regulates the lifting of the telescopic spout by keeping the swinging spout full of coal, until the heap is up to the hatches. By this mode of shipping, 250 tons of coal per hour can be placed in the vessel's hold. After the heap of coals has been run up to or near the level of the hatchways, the telescopic spout is taken out, and loading proceeds in the usual way.

(2) *Vendin la Viel Wharves, France.*—The surroundings of the Pas-de-Calais coal-field, France, are such that the pits are in communication with the whole of France by canal. From the wharves at Vendin la Viel, the journey to Paris and back occupies about fifty-nine days; the coals after leaving the wagons are teemed into a chute of great width, terminating at the lower part in a kind of funnel, which leads the coal into articulated pipes. This is fitted with a movable spout, worked from the upper part of the quay, which allows the coal to be teemed in the middle or on either side of the boat without any prejudicial effect, despite the fall of 50 feet from the quay to the boat. The tippler is hereinafter described, and an endless towage-chain arrangement mechanically moves the boat its entire length, to and fro, during teeming operations, thus allowing complete and regular loading by mechanical means, and entirely dispensing with trimming operations.

The boats or barges in use each carry about 250 tons of coal.

(*D*) *Side-tip Wagons with Fixed Shoot.*

(1) *The Bethune Collieries Company's Wharf* at Bassee was opened in 1883, and comprises a basin 1,050 feet long and about 74 feet wide, with a depth of 6 feet 11 inches, and connected with the canal by a short branch.

* *Trans. Inst. M. E.*, vol. xv., figs. 4, 5, and 6, plate xv.

One side of the basin is used for the unloading of timber; on the other side are numerous sorting roads, which facilitate the work of sorting the wagon with the least labour. Two automatic tipplers are here arranged, capable of turning, by the action of gravity alone, a wagon carrying 10 tons.

The tipplers were described and illustrated in a paper on "The Bethune Collieries," by the late M. Walton Brown.* Each of these tipplers is composed essentially of a cradle constructed of T- iron, connected together by strong beams forming the platform to receive the wagon. There is a movable buffer attached to each end-beam, *a*, *b* (Plate LXVII., Vol III.), worked by a screw, and applied against the side of the wagons when in position, so as to avoid their derailment whilst being emptied. On the other end of the side-beams, *a*, *b*, is fixed by the connecting rods, from which they are hung, an arrangement of counterbalance weights, which are used when at rest, and are placed upon a series of steps, and come into action successively during the period of tipping. These counterbalance weights are used to reduce the acceleration of the tippler during rotation, and to return the tippler to its horizontal position when the wagon is emptied. The apparatus rests upon two longitudinal shafts, whose axis is about 4 inches from the centre-line of the railway. This divergence constitutes the motive power for turning the loaded wagon and tippler, and causes the centre of gravity to rotate at that distance from the axis.

The working of the machine is very simple:—The apparatus being maintained in position by a bolt, the wagon is placed upon the platform; when the wagon is supported by the movable buffers, the bolt is opened, and the apparatus rotates until it reaches the angle of 35 degrees, ready for the unloading of the coal. It is fixed in this position by means of the brake, worked by an endless chain put in action by the last counterbalance weight—a necessary precaution—so that the wagon shall not be completely emptied of coal. The side-doors of the wagon are opened, and the coal slides out; and, when the wagon is emptied, the brakes are raised, the counterbalance weights descend, and, as they are heavier than the empty wagon and platform, both are restored to the horizontal position.

In practice, it is found that a gentle uniform movement of

* *Trans. Inst. M. E.*, 1891, vol. iii., page 1,018.

the apparatus is not obtained, as the conditions are endlessly varied, owing to changes in the weight of the wagons; their load is rarely the same, and the coefficient of friction varies with moisture and the presence of coal-dust, etc. The variations, however, are overcome by the use of a hydraulic regulator (the details of which need not be described), placed under the tippler underneath the foundations and shown in section in Fig. 1 (Plate LXVII., Vol. III.). It may, however, be mentioned that the piston of the pump moves with the tippler, and that the piston-rod is fixed in the masonry of the foundations. The liquid used is ordinary oil, in order to avoid the effects of frost. The internal pressure sometimes rises to 280 pounds per square inch whilst at work.

Trimming operations are dispensed with, and the complete and regular loading of the boat is obtained by mechanical means, consisting of a towing-chain and driving-gear. The chain transmits to the driving-gear the motive power that it receives from a small engine placed at the end of the quay, which also is used to pump water. This chain is endless, moves constantly in the same direction along the length of the quay, and is supported by the driving-gear and the small pulleys placed between them. The driving-gear is shown in Figs. 3 and 4 (Plate LXVII., Vol. III.) in plan and elevation. It consists of three loose pulleys, C, C, and E, upon the same hollow shaft: the rim of the middle pulley, E, is shaped to receive the haulage chain; each of the two side-pulleys, C and C, can be geared separately with the central pulley, and participate in its rotation. For this purpose the central axis must be moved in one direction or the other. A bronze screw, which is fitted at each end, moves the two pulleys either to or from the central pulley, with which one of them gears by friction alone. The action of the two screws is simultaneous: that is to say, as one pulley approaches and engages with the central wheel, the other moves away and becomes ungeared; and, whilst in the middle position, the two pulleys are both ungeared and at rest. If cords are wound upon each of the side-pulleys, and in the same direction, whose free ends are attached to each of the ends of the same boat, it becomes possible to move this boat in the direction of its length by turning the central axis in the desired direction. The pulley becomes geared with the motive pulley, the cord laps

on, drawing the boat, whilst the pulley at the other side, being ungeared, runs loose upon the axle, and an equal amount of rope runs from it. The motion in the opposite direction is obtained by turning the axle in a contrary direction, and stopped by turning the axle and disengaging both pulleys. The gearing is shown in this position in Figs. 3 and 4 (Plate LXVII., Vol. III.). The necessary movement is communicated to the axis of the three pulleys by means of a toothed wheel and an endless-chain, worked by the man who has charge of the end of the spout.

One of these appliances is placed under each spout; and each tippler readily loads 120 tons per hour. The wagons are moved by gravity, and the cost of labour is less than 1s. 4d. per ton. The plant has loaded upwards of 400,000 tons per annum, and is capable of loading double that quantity, if desired.

(2) *Lens Colliery Company's Wharf, Vendin la Viel.*—Here a slightly different system of tipping the loaded wagons is adopted. The full load is brought along the teeming track, and then by means of a small crane, attached to a small locomotive running on an inner track, the wagons are rapidly tipped sideways into hoppers, the feeding-holes of which are spaced very near together, so that several wagons can be tipped one after the other consecutively. The wagons stand at rest before another run is brought forward in position. Formerly, the loading of a boat carrying 250 tons required the labour of one hundred workmen for one day; now ten workmen can load 2,500 tons in the same time.

(*E*) *Tipplers.*

(1) *Timothy-Long Tippler.*—In American practice the problem of rapidly unloading long cars of the flat-floor or gondola type has engaged much attention, several installations of an elaborate character having been laid down. One example was designed by Mr. Timothy Long of the Excelsior Iron Works, Cleveland, Ohio, and can be seen in successful operation at the Erie Railway docks, Cleveland. The car enters a large cylindrical structure having latticed sides; it is then locked to the rails by hydraulic power, and the cylinder is rolled over to teem the contents over the side of the car into a series of buckets, which are then handled by means of a crane. The capacity of this machine is stated to be 300 cars or 7,500 tons

per day of 10 hours, and it has unloaded three cars (American bogie) into a vessel in 3 minutes.

With an apparatus of this kind, the rail level can be either several feet above the quay or at quay-level. The tipping cylinder is raised at each operation to the height of the shoot-hoppers, and is then allowed to roll back under the control of the cables.*

(2) *Brown Hoist-tippler.*—Another example, as worked in America, is designed and made by the Brown Hoisting and Conveying Machine Company. The coal is brought by railway in open bogie-wagons holding 28·8 tons. The wagon is run on to a tippler, and the contents transferred to six tubs or skips, each holding about 4½ tons. These six tubs or skips, all carried on one underframe, are then run to the wharf and lifted one by one by an overhead crane, traversed, and lowered into the ship's hold. Two overhead cranes are ample to handle 5,000 tons in 10 hours, and the tipping device is able to handle twice as much. Therefore, with the simple addition of two extra overhead cranes, one car-dumper would have a capacity of 10,000 tons in 10 hours.†

It was proposed to adopt this system for the Kidderpore docks, Calcutta, and the estimate for the plant required for the equipment of six berths was as follows:—‡

	£ s. d.	Rupees.
2 Tipplers	31,850 0 0	477,750
4 Short-crane conveyors for two berths with quay-walls	25,190 8 0	377,856
6 Long-crane conveyors for four berths with timber jetties	46,425 4 0	696,378
30 Tub-wagons	11,024 0 0	165,360
190 Tubs	18,620 0 0	279,300
3 Winding-locomotives	2,572 12 0	38,589
6 Tub-wagon locomotives	15,435 4 0	231,528
5 Plants for racking	7,350 0 0	110,250
Total cost of plant	£158,467 8 0	Rs.2,377,011

* For a complete description of this machine, see *Engineering*, 1896, vol. lxii., page 241.

† A very good series of views, showing the action of this tippler and the delivery of the tubs, is given in the *Colliery Guardian*, 1901, vol. lxxxii., pages 1109-1112.

‡ See *Report by the Committee appointed by the Government of Bengal to investigate the Circumstances connected with the Shipping of Coal at the Kidderpore Docks*, Calcutta, 1901.

(3) *McMyler Tippler.*—A third type in American practice is illustrated in a paper by Mr. J. D. Twinberrow, and is known as the McMyler patent.* It consists of a steel tower having vertical legs, *A*, fixed near the coping of the quay-wall; these are braced to inclined back-stays, *B*. The legs, *A*, carry vertical guides for the cradle, *C*; this has an upright side towards the water and a horizontal platform to receive the car parallel to the line of the quay. This cradle is raised by two series of wire ropes, of which one set, *D*, is secured near the upper part of the legs, *A*, passing thence downward and under pulleys attached to the lower surface of the platform of the cradle, thence to pulleys fixed at the top of the tower, returning to a winch at the ground-level. The second series of ropes, *E*, are attached to the vertical side of the cradle, whence they pass directly upwards over guide-pulleys, and downward to counter-weights, *F*, which travel on the inclined back-stays, *B*. The cradle is raised by the combined action of the winch and the counterweights, it travels vertically upwards until its top edge meets with stops fixed to the guides; these arrest the motion of the counterweights, but the winch continues to rotate, hauling on the ropes, *D*, thus turning the cradle over about the stops fixed to the guides, as shown by the dotted lines in the figure. This movement brings the curb of the car-side into contact with the ropes, *E*, the tension of which binds the car securely to the rails of the cradle. The load is then discharged into the inclined conveying spout, *G*, which delivers into the telescopic tube, *H*, passing into the hatchway of the vessel.

Two objections have been urged against this method of unloading: first, that the side of the car will be damaged by its having to support the whole load as it approaches a horizontal position, and, secondly, that the oil will run out of the axle-boxes. The first objection may be overcome by swinging the cradle to support the side of the car, whilst the second difficulty is largely a matter of axle-box design, with the employment of cotton-waste soaked in oil as a lubricating material, thus dispensing with any free liquid to swill about inside the box.

On the other hand, the undoubted advantages of bottom discharge are tending to the increased adoption of hopper wagons

* *Proceedings of the Institution of Mechanical Engineers*, 1901, vol. ii., page 574, and fig. 24, plate lxxxiv.; and *Engineering*, 1901, vol. lxx., page 716.

in the United States, to the exclusion of the flat-floor type for the carriage of minerals. It is sometimes assumed that the hopper type of wagon is suitable only where natural conditions favour the construction of staithes with easy approach gradients; there is, however, no reason why this class of wagon should not be raised to the necessary elevation by means of vertical lifts.

(F) Belts.—Conveyor System.

(1) *Robins Belt-conveyor System.*—Fig. 33 illustrates another system of speedy shipment: that is, a series of conveyors laid down by the Dominion Coal Company at their loading wharf at Louisbourg. Storage-bunkers have been built underneath the approach to the wharf, capable of holding 10,000 tons of coal, the wagons from the company's pits being emptied direct into them and then sent back to the colliery.

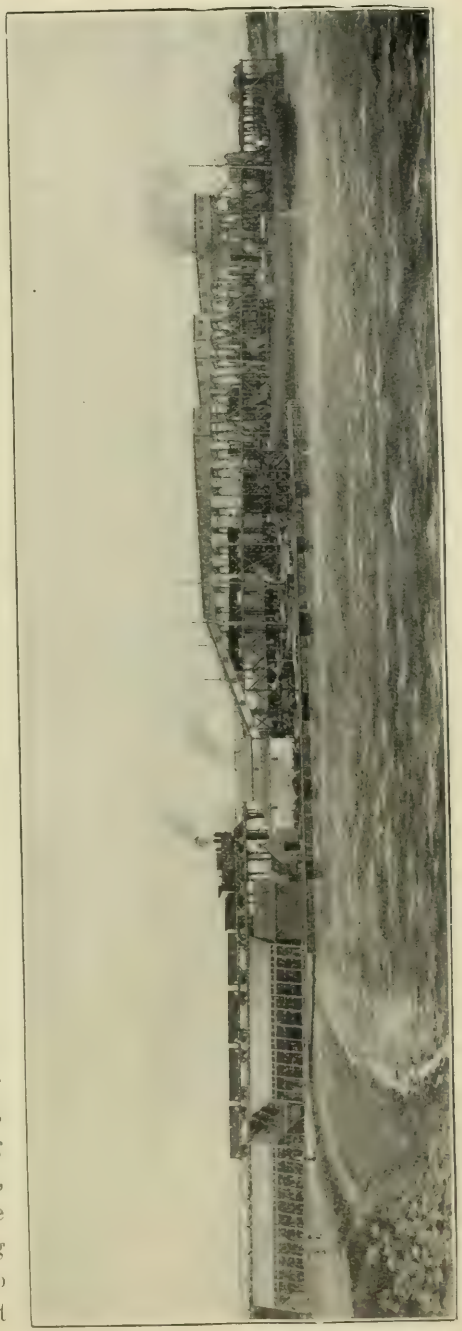


Fig. 33. Robins Belt-conveyor System, Dominion Coal Company's Wharf, Louisbourg, Nova Scotia.

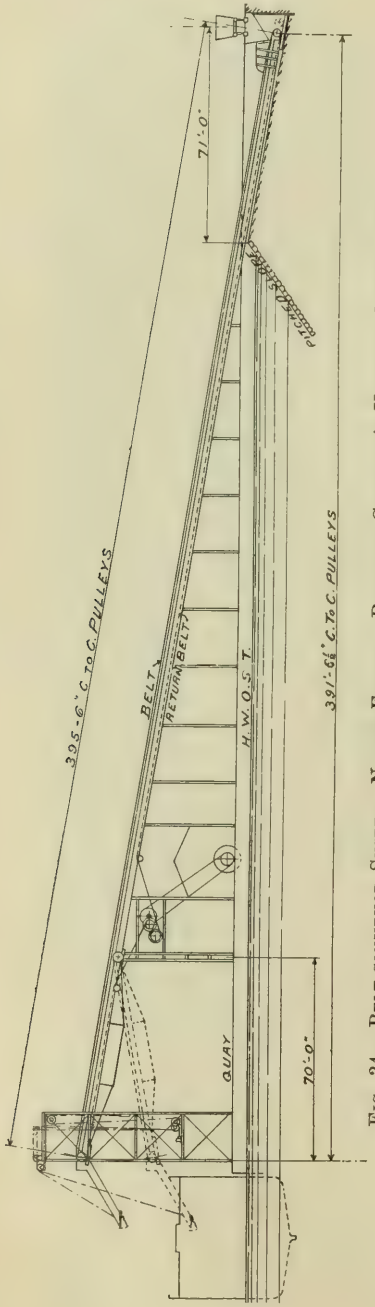


FIG. 34.—BELT-CONVEYOR SYSTEM, NORTH EASTERN RAILWAY COMPANY'S VICTORIA DOCK, HULL.

Underneath, a belt conveyor runs in a tunnel for the entire length of these bunkers, and transfers the coal at its end on to the No. 2 elevator, which raises it to a height of 30 feet above the track-level of the pier, and then discharges it on to No. 3 elevator, which runs at this height for the entire length of the pier. There are unloading devices at three or four points, by which a part of the coal can be deflected into shoots, running down into the hatches of the vessel. The conveyor is capable of handling 750 tons per hour.

(2) *Victoria Dock, Hull.*—In addition to the hoists described on page 188, the North-eastern Railway Company have recently erected, for experimental purposes, a belt for the shipment of coal.

The adoption of such a method in this country is entirely a new feature in the shipment of coal, and it has been proved to be capable of discharging large coal from railway wagons at a rate of at least 600 to 700 tons per hour.

Owing to the experimental nature of the work, the belt was erected so as to deliver coal into the spout of one of the ordinary coal-hoists, and in such a way as not to interfere with

the ordinary use of that hoist when the belt is not working. As the majority of coal-shipments made at this port are made through end-door wagons of a capacity of 8½ tons,* in order to avoid the expense of providing tipping planes, etc., in the experimental stage, the belt has up to the present been fed by a newly constructed hopper sunk in the ground, into which coal can be delivered only from bottom-door wagons (Fig. 34). The belt has not, therefore, as yet been tried under all conditions; but, from experiments made, it is found that with hoppered wagons, and with the bottom discharge in good working order, the coal can be shipped at the rate of one wagon per minute, or practically 600 tons per hour, which is faster than any of the hoists at this port. The belt, which gives a continuous feed of coal to the ship, has thoroughly answered the company's expectations, and it is intended to adapt it for permanent use with all classes of wagons shortly.

The working arrangements are as follows:—The belt-conveyor, which is wide and made of rubber and canvas (similar to, but of course much heavier than, bands which are used for conveying grain, etc.), is placed to work from underneath the hopper, and so fixed as to run out on the pier at such an inclination that the head pulley of the conveyor over which the coal is discharged is sufficiently high over the hatch of the steamers at different tides to allow of the discharge of the same. The length of this belt-conveyor between centres is 400 feet, and the last 70 feet are mounted on an arm which can swing in a vertical plane, making it possible to adjust the discharge point to any position within 24 feet corresponding with the rise and fall of the tide.

The coal is discharged over the head pulley to a shoot, which can be hoisted or lowered to correspond with the conveyor. Fig. 35 is a general view of the arrangement.

The belt-conveyor is driven by a specially designed drive, ensuring that no slip occurs between conveyor-belt and driving pulleys. The motive power temporarily is a gas-engine of 100 horsepower, situated on the pier in a motor-house; but it has been found from actual tests that the conveyor under full capacity consumes less than half of this power. After the

* The actual capacity is 10 tons, but the wagon contains only about 8½ tons of Yorkshire coal.

railway wagons are drawn over the underground discharge hopper and teemed, the coal slides on the inclined sides of the hopper down to the conveying belt. When this plant was erected, the company anticipated that difficulties would arise in discharging the large lumps of coal through the bottom door of the hopper, but the official tests have already proved that such fears were groundless.

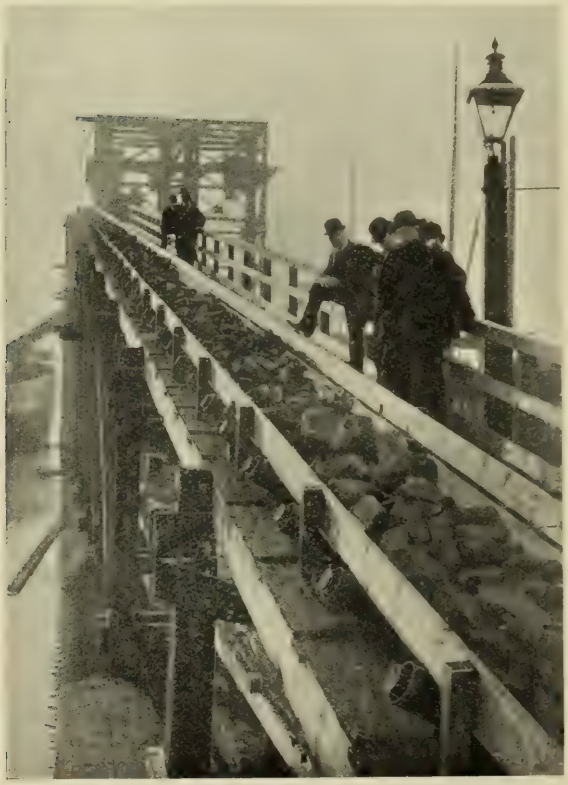


Fig. 35.—General View of Belt-arrangement, North Eastern Railway Company's Victoria Dock, Hull.

The plant being an experimental one, nothing specially had been provided with regard to obtaining a quick moving of wagons; but, in the permanent installations, special gravity roads will be provided for the full and empty wagons, and also hydraulic or electric tipping rams for discharging end-door wagons.

The general arrangement of this conveyor was designed by Mr. T. M. Newel, the dock engineer of the North-eastern Railway Company, in conjunction with the makers, Messrs. Fraser & Chalmers, Limited, London.

The two principal factors in favour of the system are the large loading capacities obtainable and the small initial cost. It is self-evident that much economy in power can also be

effected, as the railway wagons need not be lifted, but only the actual load of coal; and, as there is a constant stream of coal being discharged, and no time is lost by lifting the cars, it is clear that the capacity surpasses anything that has been accomplished up to the present moment by any single mechanical appliance. The upkeep and attendance required by this method is a minimum, as the belt-conveyor consists of two parts only, the moving belts (Fig. 35) and the stationary supporting rollers (Fig. 36). At the present moment it has been decided to instal various plants of this type in this country.

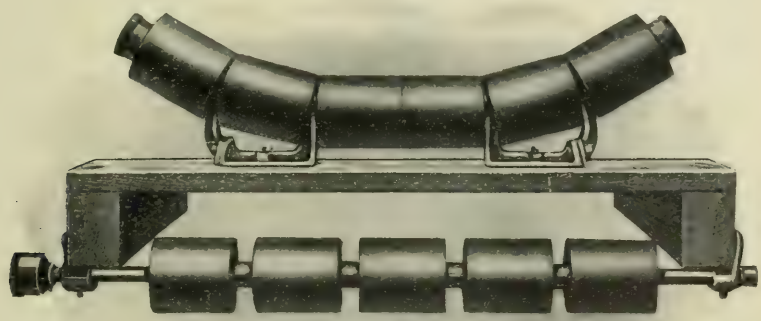


FIG. 36.—BELT-CONVEYOR SYSTEM, VICTORIA DOCK, HULL: VIEW OF STATIONARY SUPPORTING ROLLERS (OR IDLERS).

(3) *Installations under Typical Conditions.*—Messrs. Fraser & Chalmers have also just designed a large plant on similar lines for another large railway company in this country. As this plant is intended to be laid down under somewhat typical conditions, it will probably be of some interest to give a short description of the arrangements.

The coal will be stored in wagons in a field near the quay, and discharged at four points on the quay front: the two outer shoots being stationary, whilst the two inner shoots are to be movable. The distance between the two outer shoots will be about 590 feet.

The field is arranged with four separate sets of tracks, all branching off to two main lines. Each set of track con-

sists of three tracks for full wagons, and one track for empty wagons. The total storage capacity of the field will be 9,900 feet of full track and 5,600 feet of empties track. Four underground hoppers will be used in connexion with the two stationary and two movable shoots at the quay front, each shoot being guaranteed to deliver 500 tons of coal per hour of any size that may be ordinarily shipped. The three full tracks will combine again in one single track directly in front of a turntable, in order that if necessary any wagons provided with one end-discharge door only may be turned. A hydraulic tipping-ram is located in front of the table. This ram is made of the telescope type, and swings up the platform on which the full coal-wagons stand, so that after the door has been opened the coal will gradually flow out into the underground feeding hopper for the elevating and conveying machinery. When the wagon has been completely emptied, it is lowered again and pushed forward by a capstan to the end of the track, and then switched on to the track for empties. The portion of the track from the tipping ram to the switch dips slightly, in order to facilitate the removal of the empty car. The length of track from the switch to the terminus of the track has a slight incline upwards, so that the momentum of the empty wagon is consumed by the time that the wagon reaches the terminus, and it will consequently stop. This inclination upwards of that portion of the track will be helpful when the car is to run back over the switch leading to the track for empties.

It is not expected that it will be possible to do away with the capstan, as experience rather shows that, in many cases, it is difficult to get all the coal-wagons of a system to run properly on a gradient. But the arrangement of gradients will, of course, make the shifting of cars so much easier.

For this typical design four sets of turntables and tipping rams are used, one set for each of the four sets of tracks which constitutes the field.

The elevating and conveying machinery consists mainly of four elevating conveyors. These conveyors elevate the coal sufficiently high over the quay to be able to discharge coal either to one or to both shoots, or else to two of the feeding conveyors. These feeding conveyors run horizontally towards each other, and span the distance between the two stationary

shoots. The conveyors are capable of delivering their load of coal at any point along their run, so that they will be able to feed the two movable shoots at any point between the two stationary shoots. They are all mounted on steel structures, and provided with gangways for the easy inspection of the conveyors. One of the movable shoots presents features of special interest. A short conveyor is mounted on this movable steel structure, and can swing in a vertical plane around the end-pulley shaft at the feeding end; it receives its proper load of coal through a shoot, from one of the receiving conveyors. The swinging conveyor is so designed that its discharge end can be placed in position to correspond with the tide and the position of the vessel to be loaded, thereby saving breakage of coal.

The conveyor discharges to an ordinary shoot attached to the end of the former. As a comparatively small quantity of coal is discharged at a time, there is less breakage than when a whole truck-load is discharged from a great height at a considerable speed. It is intended to use light shoots within the vessel itself, for further directing the stream of coal to the sides of the hold, which is quite feasible with a comparatively light stream of coal, but would be impossible if a whole truck-load were discharged at a time.

Anti-breakage boxes will work well in connexion with this system, and would be suspended from derricks mounted on a steel structure. The shoot and swinging conveyor is operated by an electric winch located in a driver's cabin, so that the operator will be able to overlook the entire operation.

The movable steel structure for the shoots is so designed that it will allow the placing of two tracks on the quay front. These tracks may be used for ordinary light traffic, and are quite independent of the track for the coal traffic. Such an arrangement will be found useful in most cases.

The conveyors are all of the Robins type, using belts 48 inches wide. The troughing idlers (Fig. 36) are of a new and patented type, having five shafts and seven pulleys, placed in such a way as to present an ideal troughing surface for the belt. The belts are made of canvas and rubber, with an additional heavy layer of rubber on the middle of the carrying side, where the belt is exposed to heavy wear.

Each of the conveyors has a capacity of 1,000 tons of run-of-mine coal per hour, and the total power necessary to drive the entire plants at full discharging speed is about 400 horsepower. There is no doubt in the minds of the designers that this quantity of coal can be dealt with on one belt, so that the limit of speed will not be one of discharging from the shoot, but one of receiving and trimming the coal in the steamers' holds. As, however, the tendency is to provide new colliers with as many hatches as possible, and of the largest possible size, this new and greatly improved method of shipping coal should be applicable in most localities, and should cause the least possible amount of breakage of the coal combined with the minimum amount of risks of shut-downs due to breakage, as the conveyors consist only of a movable belt and stationary supporting rollers.

Another feature of interest is that each of the four elevating conveyors is provided with a continuous automatic weighing-machine, which will record the weight of all the coal passing over the conveyors with an accuracy of ½ per cent., so that the amount of coal discharged into any vessel can be accurately ascertained at a glance. This weigher is approved by the Board of Trade, and is known as the Merrick conveyor weightometer.*

(4) *Dunston and Tyne Dock.*—The North-eastern Railway Company have also recently laid down at their staithes at Dunston and Tyne Dock four coal conveyors, designed and made on a new principle by Messrs. C. & A. Musker, Limited, of Liverpool, with the principal object of bunkering large steamers at these places. The conveyors are of the belt-driven type, and so constructed that the coal is fed from the bottom-discharge wagons into a hopper, where it falls on to the movable belt, and so on to the vessel. They are each erected so as to deliver coal when the belt is at an angle of 40 degrees above or 14 degrees below the horizontal, and at all angles between these limits. The movable belt, or jib, which is 45 feet long, and built up of plates and angles, with chain drive, is hinged on a pivot so that it can be moved horizontally 8 feet in either direction, and can be lifted up horizontally for stowing away. A shoot is fitted to the end of the jib, and is capable of being raised and lowered

* For short description, see Appendix II., page 251.

to an angle of 30 degrees above and 40 degrees below the centre-line of the movable belt; and there is no loss of coal at any portion of the appliance or hopper, the breakage of coal being also reduced to a minimum. Each conveyor is capable of dealing with all classes of coal and coke, large and small, when the jib is at an angle of 40 degrees above the horizontal, and at the rate of 500 tons when the jib is horizontal.

The movable belt is 4 feet wide by $1\frac{1}{2}$ feet deep, and is electrically driven; the belt-driving motor is of 35-brake horsepower, and the lifting motor of 20-brake horsepower, the whole being self-contained on the staithes.

FIG. 37.—RANSOME AND RAPIER COAL-SHIPPING ARRANGEMENT, WALLSEND COAL COMPANY'S STAITHE (TYNE).

(*G*) *Cranes.*

(*a*) *Fixed Crane with Wagon:* (1) *Ransome and Rapier Arrangement at Wallsend Colliery.*—The Wallsend colliery staithe has been briefly described by Mr. J. M. Moncrieff.* It is connected directly with the colliery yard by a double line of railway, one full and one empty way. The full way falls from the colliery

* *Trans. Inst. M.E.*, 1898, vol. xv., page 75.

to the staithe head with a gradient of about 1 in 70, the wagons gravitating to the staithe head in sets. The empty way also falls from the colliery for a considerable distance with a steeper gradient than the full way, and it also falls back from the staithe head to form a bay for the empty wagons to gather in sets, to be taken to the colliery yard by locomotives. The staithe head is built approximately triangular, its base forming the river-frontage. The full and empty ways run one on each side of the staithe head, terminating in turntables, which are connected by a cross-way, there being space for two wagons to stand between the incoming and the outgoing turntables; the former of the two is directly in position under the crane, thus causing no delay in bringing each succeeding wagon up into position. The length of the staithe head is about 300 feet, its level being 35 feet above the rails at the river-front; it is about 42 feet above high-water mark, and the level at which the crane is fixed is 16 feet higher than the staithe-head level. The turntables are each 16 feet in diameter.

The coal is conveyed from the colliery yard to the staithe head in steel-plate boxes, each holding 5 tons, and resting without any connexion on low trucks with light steel frames. These steel boxes are provided with sprocketed trunnions (wheels 2 feet in diameter and containing 25 teeth), riveted against the two end-sides. By means of two chain loops (each end of which is attached to 3-inch wire ropes passed over pulleys in the jib, and manipulated by attachments on an hydraulic crane), the middle links of each of which are inserted round the teeth of these trunnions, the boxes are lifted clear of the wagon frames, swung out, and lowered into the hatchway of the vessel at the staithe, the inside or outside tilting of the box being accomplished by tightening either the two inner or the outer ropes as required owing to the list of the boat at the time.

The crane is operated by thirteen valves, and comprises six rams, namely, two tipping-rams each 10 inches in diameter for the outside tip, one pendulum ram $5\frac{1}{2}$ inches in diameter for travelling the pendulum jib, which is hinged on to the end of the main jib; the other three rams being connected together by means of a cross-head, the main one (8 inches in diameter) raising or lowering the box as required, and the remaining two pump-rams (each $4\frac{1}{2}$ inches in diameter) giving power to the crane by forcing water back to the accumulator during the time when the main ram is

raising or lowering the box. The travel of each ram is 14 feet. The maximum outside travel of the pendulum jib is 28 feet; but this distance can be regulated to any length, according to the width of the vessel, by means of valves and a fusee barrel. The length of the main jib is 63 feet, at the end of which the pendulum jib, 50 feet long, is hinged. An automatic arrangement, acting

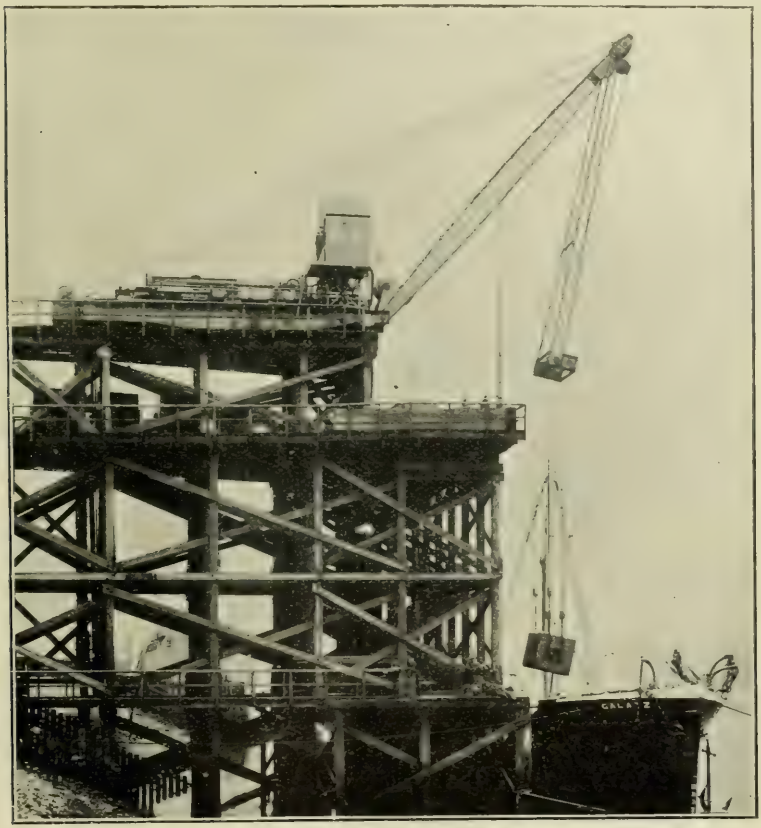


Fig. 38.—Ransome and Rapier Coal-shipping Arrangement, Wallsend Coal Company's Staithe (Tyne).

on the main ram, can regulate the distance over which the box has to travel before tipping (Fig. 38).

At ground-level is placed the wooden water-tank fed with town's water, and fixed alongside a pair of steam cylinders (in duplicate) 5 and 12 inches in diameter, working two separate $2\frac{1}{4}$-inch rams, forcing water at 80 pounds per square inch into the

accumulator, and thus starting it. The accumulator weighs 80 tons, and forces to a height of 14 feet by a ram 15 inches in diameter, at which point the pressure is caught by the main ram operating the crane. Pumping power is derived from two tubular boilers, each 12 feet long and 4½ feet in diameter.

The plant and crane were designed and erected by the makers, Messrs. Ransomes and Rapier, Waterside Iron-works, Ipswich.

On one occasion when tested, when there was a clear teem and no waiting on trimming, the crane shipped 245 tons (or 49 wagons) per hour. With clear hatchways, the average rate is 70 boxes (or 376 tons) per 2 hours, equal to 188 tons per hour; and, as the succeeding wagon is always close up before the preceding box can be replaced on the bogie, no delay is experienced through getting the wagons into position.

This system, however, only admits of teeming being done into one hatchway at a time, the vessel requiring to be shifted for loading each hatchway; and, unless the hatchways are large, it is necessary to tip the boxes at the level of the coamings. But it is claimed that very large boats can bunker here on account of the height.

(2) *Bramley-Moore and Wellington Docks, Liverpool.*—Liverpool necessarily has a very considerable trade in coal on account of its proximity to the Lancashire and North Wales coal-fields, the immense quantity of bunker coal required for the steamers trading to the Port of Liverpool, either as regular liners or otherwise, and owing to the fact that vessels coming to Liverpool with import cargoes may readily obtain cargoes of coal for export. The port contains docks and basins covering an area of about 442 acres, all the property of the Mersey Docks and Harbour Board, with the exception of the two Garston docks belonging to the London and North-western Railway Company.

The special accommodation first provided for the coal-trade at this port consisted of a viaduct extending along the eastern ends of the Bramley-Moore and Wellington Docks, in communication with sufficient siding accommodation provided on the railway system at no great distance from the docks. It was erected in 1855, and provided with four hydraulic cranes, two of 14½ and two of 10½ tons lifting capacity. The first two cranes were replaced in 1881 by two others, each of 23 tons power.

This viaduct has since been extended by running a branch down the north side of the Bramley-Moore dock, on which five hydraulic cranes, four of 24 tons and one of 30 tons power, are erected (Fig. 39). The whole of this system is now in constant work, shipping coal for bunker or export purposes.

The wagons which are used for this railway are of two classes, some being of the ordinary type, of 8 and 10 tons capacity, and the others consisting of three compartments or boxes, each of a capacity of $3\frac{1}{4}$ tons, set on a common body of the usual wagon size. In the latter case, one box is lifted by the crane at a time and lowered into the hold of a vessel, where the contents are discharged by the letting go of the doors forming the bottom of the box, the method being somewhat similar to that in operation at the Wallsend Coal Company's staithe on the River Tyne.*

In the case of the full-sized wagons, the wagon is run on to a special cradle, the cradle with the wagon on it being lifted and lowered to the hatchway of the vessel, where the wagons are discharged by the tipping arrangement, which lifts one end of the wagon while the hinged door at the other end is opened for the discharge of the coal.

(*b*) *Travelling-crane with Wagon (end-tip): McMyler Car-dumper.*—This machine is constructed by the McMyler Manufacturing Company of Cleveland, Ohio, U.S.A., and a plant is at present in operation at the Cleveland docks, Ashtabula, Ohio. The essential feature of the machine is a tilting platform or "see-saw," supported on trunnions near its centre of gravity, and mounted on a turntable to allow of turning or swivelling when required under load The whole is carried on four bogie-trucks (two on each side) running on two lines laid with centres about 20 feet apart. These tracks are laid along the edge of the wharf, and the vessel to be loaded is moored alongside, so that the short arm of the tilting-bridge is over the vessel's hatches.

Opposite the dock, and at right-angles to it, several lines of railway tracks are laid. In the arrangement at Ashtabula, six double lines of tracks are laid, which are spaced about the same as the hatches of the vessels commonly served. In operation, the vessel is placed so that the hatches are opposite the tracks, or nearly so, and the machine is moved opposite the hatch into which it is desired to load; a steel cable is hooked into

* See page 187.

FIG. 39.—LIVERPOOL HIGH-LEVEL COAL RAILWAY, NORTH SIDE OF BRAMLEY-MOORE DOCK.

the drawhead of the car, and the car pulled up to the upper or shorter end of the bridge, which is so constructed as to form a bumper against which the end of the car rests when tilted. The bridge is then tilted; at the same time the end-board of the car is automatically withdrawn, and the coal flows out through a discharging shoot, and is concentrated in a telescopic trough or spout, which may, if desired, be lowered to within a few feet of the bottom of the vessel. After the load is discharged, the bridge is tilted back, the cable is detached, and the car is allowed to run down and off the incline on to the track provided for empties. Another loaded car is then taken up, and so the operation continues, the machine moving from one set of tracks to another and from one hatch to another, as may be required, by supplies of loaded cars, or to permit of the trimming of the cargo. The machine can be moved laterally in either direction with a car on the bridge or platform, and it may also be swung at the same time to avoid spars or any other obstructions on a vessel.

The machine at the Cleveland docks has loaded fifteen bogie car-loads (equal to 345 tons) in an hour, and steamers of from 2,000 to 3,100 tons capacity have been loaded in 8 to 12 hours.*

(2) Low-level System with Hoists or Elevators.

(A) Elevator and Shoot (end-tip wagon).

(1) *Scotland: Hoist System.*—Prior to the laying out of the Barry-dock works, the following tables (I. and II.) of comparison, showing the rates of shipment with the different machines operating under the low-level system of shipping coal in Scotland, were obtained by the instructions of Messrs. P. W. and C. S. Meik, consulting engineers, Westminster, London, S.W.†

From the discussion on Mr. Robinson's paper‡ and Tables I. and II., it can be gathered that all the appliances contained

* For illustrations and further particulars of this plant, see articles in *The Engineering Review*, *The Engineering News*, and *The Railroad Gazette*, 1894.

† "The Barry Dock Works, including the Hydraulic Machinery and the Mode of Tipping Coal," by John Robinson, *Minutes of Proceedings of the Institution of Civil Engineers*, 1890, vol. ci., page 129.

‡ *Minutes of the Proceedings of the Institution of Civil Engineers*, 1890, vol. ci., page 177.

TABLE I.—LOW-LEVEL SYSTEM OF SHIPPING COAL: RATES OF SHIPMENT WITH DIFFERENT MACHINES IN SCOTLAND.

Example.	No. 1. Queen's Dock, Glasgow.		No. 2. Burntisland Dock. No. 2 hoist, first test.		No. 3. Burntisland Dock. No. 3 hoist, second test.		No. 4. Burntisland Dock. No. 4 hoist.		No. 5. Grangemouth Dock.		No. 6. Boness Dock.	
Kind of machine	20-ton hydraulic crane, having small oscillating rams geared to cupped sheave, with cradle for lifting and slewing wagon over hatchway		15-ton hydraulic coal hoist, with direct lifting and tipping rams under cradle; emptying coal into a movable shoot.		Same as No. 2		15-ton hydraulic coal-hoist, with two overhead lifting rams attached to cradles by wire ropes, and tipping ram under cradle; emptying coal same as No. 2.		15-ton hydraulic coal hoist, with direct lifting and tipping rams under cradles; emptying coal same as No. 2; 27 feet lift		Same as No. 4	
Makers	Sir W. G. Armstrong, Whitworth, & Co.		Sir W. G. Armstrong, Whitworth, & Co.		Same as No. 2		Brown Bros. & Co.		Sir W. G. Armstrong, Whitworth, & Co.		Brown Brothers & Co.	
Railway sidings	All level—wagons worked by capstans		All level—wagons worked by horses.		Same as No. 2		All level—wagons worked by capstan and horse		Self-acting gradients—wagons worked by gravitation		Self-acting gradients—wagons worked by gravitation and capstan	
Speed table (each operation)—	Mins.	Secs.	Mins.	Secs.	Mins.	Secs.	Mins.	Secs.	Mins.	Secs.	Mins.	Secs.
Lifting wagon	0	41·0	0	13·25	0	25·4	0	40·8	0	20·33	0	14.6
Slewing	0	27·0	—		—		—		—		—	
Tipping	0	25·4	0	14·50	0	25·2	0	43·7	0	14·83	0	28·3
Slewing back and depositing wagon	0	35·3	—		—		—		—		—	
Lowering wagon[3]	—		0	19·75	0	23·2	0	54·8	0	14·22	0	46·2
Removing light wagon and turning and placing loaded wagon on cradle	1	18·0	1	2·50	1	6·4	0	40·7	0	12·50	1	0·4
Total time per wagon	3	26·7	1	50	2	20·2	3	0	1	1·88	2	29·5

Actual number of wagons shipped per hour, including stoppages	18		33		26		20		58		24	
Load per wagon	8 tons		8 tons		8 tons		8 tons		7 tons [1]		8 tons	
Actual shipment per hour ...	144		264		208		160		406		192	
Level of coaming of ship's hatchway	5 feet above quay		Quay-level		8 feet above quay		5½ feet above quay, and 7½ feet		7½ feet above quay		1½ feet above quay	
Height of lift of cradle	about 8 feet		7 feet		15 feet		13 feet & 15 feet		14½ feet [5], and afterwards up to light line		8½ feet	
Men employed at each machine	5 men, 1 capstan		6 men, 2 horses		6 men, 2 horses.		5 men, 1 boy, 1 horse, 1 capstan		6 men, 1 capstan		5 men, 1 capstan	
Average time of wagon on cradle	Mins. 2	Secs. 8·7	Mins. 0	Secs. 47·5	Mins. 1	Secs. 13·7	Mins. 2	Secs. 19·3	Mins. 0	Secs. 49·38	Mins. 1	Secs. 29·1
Average interval	1	18·0	1	2·5	1	6·5	0	40·7	0	12·50	1	0·4
Total time per wagon	3	26·7	1	50·0	2	20·2	3	0	1	1·88	2	29·5

Notes to Table I.—In none of the above tests was there any waiting on account of trimming. All the wagons were end-tippers, being open at one end only. A test of No. 3 hoist, Burntisland dock, with height of lift of 13 feet, gave the same result as example No. 3, under less favourable conditions. Examples Nos. 2, 3, and 6 were loading spar-decked steamers; all others well-decked steamers (a spar-decked steamer is one with two decks laid and no bulwarks; a well-decked boat has only one deck laid and a well and bulwarks). In No. 4 example the arrangement of rails was more favourable than in Nos. 2 and 3 at the same dock. In Nos. 1 and 6 examples most of the wagons had to be turned through a semi-circle. In Nos. 2, 3, and 4 examples all the wagons had to be turned through a quadrant. In No. 5 example all the wagons had to be partly turned.

Example No. 1: These hoists are described and compared in the discussion and correspondence on Mr. John Robinson's paper in the *Minutes of the Proceedings of the Institution of Civil Engineers*, 1890, vol. ci., page 178.

Example No. 2: Gradient of load lines, 1 in 100; light line, 1 in 80; wagons left hoist 15 feet above quay level.

Example No. 3: "Lowering" included back-stroke of tipping rams.

Example No. 4: Taking this at 8 tons, as in all the other examples, would give a shipment of 464 tons per hour.

Example No. 5: Quay level was too low—3½ feet above high water of ordinary spring tides—necessitating increased height of lift.

Example No. 6: These hoists are described in the *Minutes of the Proceedings of the Institution of Mining Engineers*, 1882, vol. lxx., page 369, and plate xv.

TABLE II.—AVERAGE SPEED OF LIFTING AND LOWERING CRADLE WITH LOAD.

Examples.	No. 1.		No. 2.		No. 3.		No. 4.		No. 5.		No. 6.	
	Mins.	Secs.	Mins.	Secs.	Mins.	Secs.	Mins.	Secs.	Mins.	Secs	Mins.	Secs.
Lifting 1 foot in	0	5·12	0	1·9	0	1·7	0	2·9	0	1·40	0	1·70
Lowering 1 foot in		*	0	1·52	0	1·1	0	2·74[2]	0	0·70[3]	0	3·19[2]
* Included in back-slewing												

NOTES TO TABLE II.—Example No. 1: Low speed due to gearing between engine and chain sheave, and to multiplying sheaves.

Example No. 2: Very slow; caused principally by tipping rams having to force return-water back to engine-house tank.

Example No. 3: Higher speed obtained by running return-water to dock.

Example No. 4: A height of 6 feet is added to that of the lift for the back-stroke of the tipping rams.

therein were upon the low-level system, and, with the exception of Glasgow, the docks were of such a size as to accommodate only vessels of moderate tonnage. The results were obtained in the ordinary course of working, no special preparation having been made with a view to speed tests, so that they may be taken as representing fairly the ordinary work of the machinery. It happened, however, that in no case was there any stoppage for trimming, as in some cases the vessels were "self-trimmers," and in the others the "cone" below the hatchway was being formed when the speeds were observed. It will be seen that, if speed of shipment were the only consideration, cranes would not be able to hold a place.

In all examples but No. 1, the appliances were all of the same type, namely, hydraulic lifts, but although there were considerable differences in the speeds of the mechanism (Table II.), heights of lift, etc., it would be found that the great saving of time in the intervals between the wagons at Grangemouth was the principal reason of the very high speed obtained there.

The saving of time was effected chiefly by the high-level line for taking off the light wagons, and partly by the self-acting gradients for bringing on and taking off the wagons. The arrangement, which had been adopted in none of the other cases, enabled a loaded wagon to be brought forward, turned, and placed in position close up to the hoist framing with the capstan rope attached, all ready for placing on the empty cradle as soon as it reached the quay level, while the previous wagon was being raised and emptied. Another considerable source of the saving of time in the Grangemouth hoists was obtained by sending the return-water to waste into the dock, instead of to the engine-house

tank, which was a source of considerable delay in examples Nos. 4 and 6. Perhaps in no district were steamers more rapidly loaded than in the North of England under the system of high-level spouts, but Mr. Kidd, in the discussion on the paper, thought this rapidity was chiefly due to the simultaneous loading at more than one hatchway, which method was universal in that district, whereas at the Scotch ports only one hatchway was in use at one time. By the use of some system of anti-breakage appliance for forming the "cone," it was obvious that much breakage previous to the coal reaching the hatchway was avoided by the crane.

With a view to retaining the great advantage of cranes in the matter of minimum breakage, Mr. Kidd said that he had been led to suggest a mode of increasing the speed of shipment by employing what might be termed a "double jib-crane." It was a development of the design of the cranes employed at the Roath dock, Cardiff, designed by Sir W. G. Armstrong, Whitworth, & Company, Limited, and it should be provided with the same ingenious auxiliary appliances. It should be movable, travelling on wheels, but resting on four hydraulic jacks while working. It would, therefore, have to be provided with two Westmacott coaling-cradles, which enabled wagons to be lifted and deposited at any point on a line of rails. It should also have the swivel arrangement which enabled the wagons to be turned while suspended by the crane. At the Roath dock it was found that a wagon could be shipped in from $2\frac{1}{2}$ to 3 minutes. By the double-jib crane, two wagons could be shipped in that time: as while at one end the wagon was being emptied into the hatchway, at the other the light wagon could be taken off and a loaded wagon placed on the cradle. In addition to a second jib and cradle, only one second set of lifting and tipping cylinders would be required. The distribution of strains in such a crane would be good, the difference in the counter-balance being only the weight of the coal in the wagon. Two men would be required to work the machinery. Mr. Kidd proposed to apply two such cranes to each moderately sized vessel, and three to each large one. Taking the wagon-loads at 8 tons, and allowing the same time for each revolution as at the Roath dock, two wagons would be shipped in $2\frac{3}{4}$ minutes, which gave 348 tons per hour for each crane.

An important advantage resulting from the use of movable cranes was, that each vessel required but little more than one-half the length of quay necessary with a fixed machine. In the former case, it was not necessary to move the vessel, and in the latter a ship 300 feet long required a length of 550 feet, in order to shift ahead and astern, so as to bring the hatchways under the shoot where only one machine was employed to each vessel, as at Glasgow. A further advantage of the Glasgow cranes over other coal-shipping appliances was their frequent employment in the shipment of machinery.

(2) *North of England: Albert and Victoria Docks, Hull.*—The amount of coal shipped from the port of Hull has increased from 1,314,555 tons in 1894 to 3,160,680 tons during 1907; the tonnage for the second half of 1907 amounting to 1,734,646 tons. The North-eastern Railway Company own eight docks, including the Albert, 24 acres in extent, and the Victoria, of 20 acres area. The Hull and Barnsley Railway Company own one dock, the Alexandra, where coal is also shipped. The Albert dock is the busiest coaling dock. The record day's shipment from Hull up to the present has been 1,642 wagons, averaged at 8½ tons capacity, equal to about 13,957 tons.

There are three types of hoists in operation at Hull, described below. The South Yorkshire and West Yorkshire average a carrying capacity of only 8½ tons, but as any hoist could as easily handle a 10-ton Northumberland or Durham wagon in exactly the same time, this difference should be noted in making any comparisons.

(1) The ordinary type of hoist is that by which the wagon is taken up to the necessary height, and its contents discharged through a hopper and spout to the ship. The maximum rate that this type of hoist handles per hour is about eighteen wagons (equal to 153 tons), but this slow rate of speed is chiefly owing to the inconvenient arrangement for getting rid of the empty wagon, which, although worked away by a capstan, has to be worked back-over, and switched clear of the track before the next full wagon can be worked forward. Consequently, this causes some delay before it can be placed over the hopper.

(2) At the Albert Dock there is a hoist which is in three sections, namely:—(*a*) A lifting table, which raises the wagon

from the quay level to the necessary altitude, at which point it is moved on to (*b*), a table and hopper, on which the wagon is tipped and the contents delivered through the hopper and spout into the ship; from this table it is passed on to (*c*), a lift by which the wagon is put down to quay level again. By these means an almost continuous shipment is possible, and this hoist is capable of dealing with about forty-five wagons per hour (equivalent to 382 tons per hour), the capacity of the wagons in operation averaging only $8\frac{1}{2}$ tons. This hoist was designed in 1871 by Mr. Mirello, the engineer of the old company that owned the dock, which was taken over by the North-eastern Railway Company in 1893, and would then be considered (as indeed it is to-day) a very good appliance.

(3) The third type is a hoist consisting of a hopper which holds 20 tons, and into which the coal is emptied at quay level; the empty wagons are then run off the hoist, after which the hopper containing the load is lifted to the desired elevation, where it is tipped at such an angle that the coal runs from the hopper into the spout. This is found to be a very good appliance, and is capable of shipping coal at about fifty wagons per hour (with $8\frac{1}{2}$-ton wagons, this is equal to from 374 to 408 tons).

The whole of these hoists are capable of dealing with either end-door wagons (for which tipping tables are, of course, provided) or bottom-discharge wagons.

End doors are dealt with in each case by means of a table worked with a hydraulic ram, by which, after the wagon has been secured on the table, it is tipped at an angle of something like 45 degrees, at which angle the coal is rapidly discharged from it.

Most of the wagons have an end door at one end only, and a turntable is therefore provided at a point immediately approaching the tipping table, so that the wagons can be turned so as to present the end door towards the hopper. The end-door wagon is thus capable of being emptied very rapidly.

There are three coal hoists in operation at the Victoria dock, and four at the Albert dock, two additional hoists being at the other docks belonging to the North-eastern Railway Company. In addition to these, there are also a number of 20-ton and

40-ton hydraulic cranes, by which coal-shipments are made.* An endless belt has also recently been erected at the Victoria dock.†

The hoists at the North-eastern Railway Company's docks at Hull have no overhead empty lines. The company were on the point of making this provision at some of their hoists before the experiments with the belt were carried out; these are proving so satisfactory that they have decided to go further into the question of belt working before deciding upon any such alterations. There are no staithes for coal-shipment at this port.

(3) *South Wales and Monmouthshire: Elevator and Shoot and End-tip Wagons.*—Welsh coal is usually shipped from end-discharging wagons, which are lifted with their centre-lines at right-angles to the line of quay by means of hydraulic hoists or tips. The platform carrying the rails is hinged to the main table of the hoist along its outer edge, and is provided with subsidiary tilting-gear to incline the wagon and discharge the load into the spout as soon as the main lifting-gear has raised the whole to a suitable level.

The hoists are either direct-acting or suspended. The former (as in operation at the Bute, Barry, and other docks in South Wales) were designed and built by Sir W. G. Armstrong, Whitworth, & Company, Limited, for the Bute docks, and by Messrs. Tannett Walker & Company, Leeds, for the Barry docks: the latter type (as in operation at the Port Talbot docks, South Wales) being generally constructed by Sir W. G. Armstrong, Whitworth, & Company, at their Elswick Works, Newcastle-upon-Tyne.

(*a*) *Barry Docks: Direct-acting Hoist.*—These docks cover an area of 114 acres, and have accommodation for the largest vessels afloat. Enormous quantities of coal are shipped at the Barry docks. The total tonnage exported from these docks in 1907 amounted to 9,910,485 tons, of which 4,906,082 tons took place during the second half, and the machines adopted (with one noticeable exception) are similar to the last described. Three of these hoists, however, are movable, and travel parallel with the quay, enabling them usually to work simultaneously in coaling

* See "Cranes," page 210.

† See "Belts," page 170.

one vessel. Each coal-tip has two weighbridges: wagons can, therefore, be weighed when full and when empty.

Fig. 40 illustrates a 20-ton hydraulic coal-hoist of the direct-acting type in use at the Barry dock. The framing is 73½ feet high by 26¾ feet wide from the dock side, 40 feet wide in front, and 23⅓ feet wide at the back at the base, the distance between the guides being 14⅓ feet. The cradles are 24 feet 2 inches long, 14 feet 6½ inches wide outside the guide, 13½ feet wide inside the opening, and fitted with a tip-table suitable

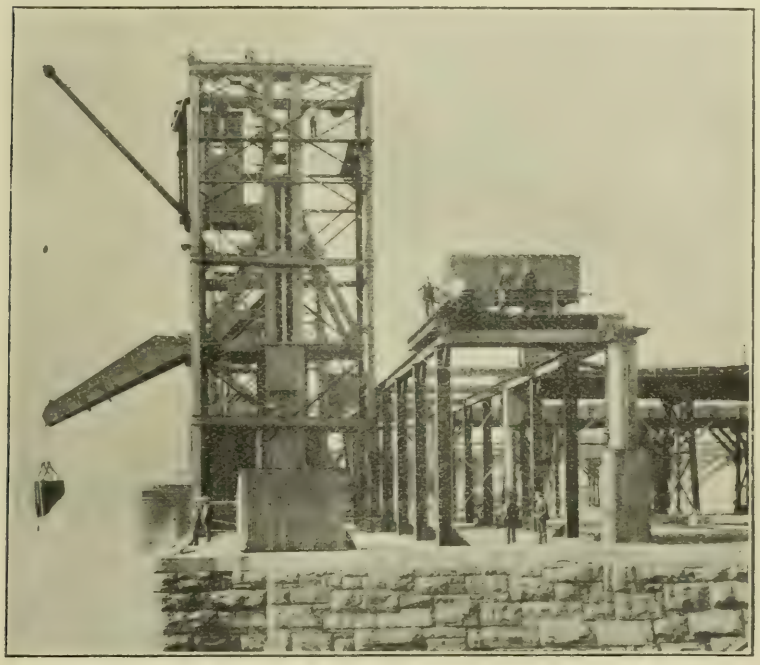


FIG. 40.—20-TON HYDRAULIC COAL-HOIST (DIRECT-ACTING TYPE), BARRY DOCK, SOUTH WALES.

for wagons of 4 feet 8½ inches gauge and 22 feet long over the buffers, and are capable of being tipped to an angle of 45 degrees. The hoist is fitted with a 4-ton anti-breakage crane, the maximum range being 30 feet, and the minimum range 12 feet, while the lift is 65 feet.

The cradle travels in the vertical guides, is raised and lowered by means of direct-acting cylinders placed between the guides, and has a lift of 45 feet.

The cradle is fitted with a tip-table hinged at the front end, and is tipped by means of wire ropes, one at each side, which are fastened to the bottom of the framing, passing around pulleys on the cradle, around pulleys on the tipping-table, over pulleys on the top of the framing, and around pulleys at the jigger cylinder fixed at the side of the framing. The pressure-water is put into the jigger cylinder, takes up the ropes, and tilts the table: the action being exactly the same as a travelling-monkey on a jib-crane. The weights of the moving parts, namely, the cradle, the rams of the cylinders, and the tipping table, are balanced by the weights running inside the guides fixed to the cradle by wire ropes. The weight of the moving parts being balanced, pressure-water necessary to lift them is saved, and the water is not forced back into the accumulator when it is at the top of its stroke, as would occasionally occur with balancing rams.

The wagons are brought on to the hoist at an elevation, lifted or lowered to the necessary height and tipped; the end-door of the wagon is then released, and the coal slides out on the spout, the floor of which is fitted with screen-bars for separating the smalls, and is fitted with doors at the end to ensure a gentle movement of coal down the spout, if required.

A jib-crane of 4 tons capacity is fixed and fitted with an anti-breakage box, which takes the coal from the end of the spout and delivers it at the bottom of the hold, until a cone has been formed to avoid breakage; the crane also returns the smalls rejected from the cargo, and delivers into the spout, charging to the small coal-wagons.

These tips have shipped 68 wagons per hour (equal to 500 tons of coal per tip).

The exceptional machine is a crane, which picks up the wagon and tips it in a manner similar to that in use at Cardiff. This crane is coupled to the railway by a large pair of girders, which form a bridge upon which the full wagons and the empty ones respectively approach and leave the crane. The apparatus appeared to be good, but it was not given a very good character. The use of anti-breakage boxes is practically abandoned at Barry.

(*b*) *Port Talbot: The suspended type of hoist* in operation here, as illustrated in Fig. 41, is in use at the Port Talbot

dock, and was constructed by Sir W. G. Armstrong, Whitworth, & Company, Limited, of Newcastle-upon-Tyne. The main platform travels in vertical guides attached to a suit-

FIG. 41.—ARMSTRONG "SUSPENDED" TYPE OF COAL-HOIST, PORT TALBOT, SOUTH WALES.

ably braced steel tower, and is suspended by means of chains, which pass over guide-pulleys and around jigger cylinders and rams. On the descent of the platform with the empty wagon, a portion of the pressure-water is returned to the mains,

thus compensating for the power expended in lifting dead weight. The rails are laid on a platform which is hinged to the main platform along its outer face, and is tilted by means of a pair of chains, which pass over pulleys on the cross-head of a smaller jigger cylinder, and also around similar pulleys on the cross-head of the main cylinder. The action of the latter thus takes in or pays out both sets of chains at an equal rate; but, when pressure-water is admitted to the jigger cylinder, the chains are drawn up and the platform is tilted; the end door of the wagon is then opened, and the load slides out on to the spout. The floor of this spout is usually formed of screen-bars to separate the smalls, and it is sometimes fitted with special devices to ensure a gentle movement of the coal down the spout. A jib-crane is usually provided for returning the smalls rejected from the cargo, and for the purpose of working an anti-breakage box, which is supposed to take the coal from the end of the spout and to deliver it to the bottom of the hold until a cone of coal has been brought up to the hatchway level. This crane could also serve to manipulate an anti-breaker of the Handcock type.

The trucks in use here hold 10 tons net (16 tons gross); they are end-tipplers, with doors at one end only, and are run on and off the cradle at quay level. The hoists will lift 19 tons, and have hydraulic cylinders on the side-framing. The lift of the cradle is 35 to 40 feet. Both full and empty trucks are weighed, the former invariably, the latter occasionally, and they gravitate to and from the hoist, but a capstan is required to work the trucks off the weighbridge and on to the hoist. A turntable is provided between the weighbridge and the hoist, as occasionally trucks arrive wrong end foremost. One complete operation with a truck can be completed in 2 minutes, and the number of men required for one hoist, irrespective of the weigh-clerk, is four. The speed of shipment depends on the height of the lift. The average shipment per hour (for, say, 10 hours) is equal to 150 tons per hour, the maximum being 300 tons per hour.

(*c*) *Penarth and Swansea.*—Very similar hoists are in operation at Penarth, but they are much hampered for room in the neighbourhood of the hoists, and the wagons are marshalled by turntables instead of the usual curves. This arrangement has

a tendency to retard work, and it also seems objectionable from the fact that when larger wagons become universal, the turntables are an additional place where renewal will be necessary; and further from the fact that any new larger wagons must gain their large size chiefly from lengthening. This renewal of turntables may involve a large outlay in widening the space between the railway-lines, that is, the 6-foot way.

Anti-breakage boxes are also much used. The total coal and coke tonnage shipped from this port during the year 1907 amounted to 4,570,429 tons, of which 2,286,013 tons took place during the last six months.

The shipment of coal from Swansea for the year 1907 was 3,655,050 tons, of which 1,918,400 tons took place during the second half of the year. All the coal-shipping at Swansea is accomplished by some form or other of hoist, which lifts the railway wagon and tips its contents into a shoot, which in its turn discharges into the vessel's hold. In the newest form of hoist, the full wagon is run on to the platform at quay level, and, after tipping, leaves the hoist by an elevated road on the incline. This platform is hoisted by a direct-acting ram, and the tipping is done by an auxiliary ram, also direct-acting, and known there as the "kicking-ram." In other hoists in course of construction, the approach arrangements are reversed, the full wagon reaching the hoist on the high and leaving it empty on the low level. This appears to depend on the level of the adjacent ground and the siding convenience. The wagons hold 10 tons, although there are a number of 6-ton wagons in use, and are fitted with end doors, the kicking-ram tilting the platform upon which the wagon is hoisted. The time for a complete round takes about $2\frac{1}{2}$ minutes, there being no difference in the time taken whether the wagon reaches the platform at the higher and leaves it at the lower level, or *vice versa*.

Each hoist is provided with a jib-crane, the dual object of which is first to handle its screenings and then to work the anti-breakage boxes. The anti-breakage box system is looked upon with ill-favour by Welsh workmen, and is very little used at Swansea, although at the commencement of a vessel's loading about half an hour's boxing is supposed to be done at each hold, that is, until a cone of coal is formed in the bottom of the vessel.

(*d*) *Bute Docks, Cardiff.*—The docks cover an area of 162¾ acres in extent, and comprize five separate docks, namely, Bute West dock, Bute East dock, Roath basin, Roath dock, and Queen Alexandra dock, opened in 1907. This latter dock is only partly equipped as yet; but there are in all sixty-two coal-shipping appliances distributed over the above docks at the present time, some of which range up to 60 feet in height from the quay level. A great number are movable, thus enabling coal to be shipped very expeditiously; and wagons up to 20 tons in capacity can be handled at some of these coaling berths. Vessels loading up to 12,000 tons regularly trade there. The total shipments of coal and coke from these docks during the year 1907 amounted to 8,909,823 tons, of which quantity 4,508,973 tons were shipped during the second half of the year. The Lewis-Hunter coaling cranes (hereinafter described under anti-breakage appliances) are in operation, as well as the fixed and movable staithes. The system of shipment at the Bute docks, Cardiff, is similar in some respects to that in use at Swansea, except that both the full and the empty wagons leave the hoist at the same level, a turnout being placed a few feet from the hoist to enable the empty wagon to get clear of the full one. Another difference is that, whereas in 1897 only one weighbridge was used for each hoist at Swansea, two are used at Cardiff, one for the full wagon and one to obtain the tare. This second weighbridge has been adopted at Swansea in the newer hoists.

The anti-breakage box system was first used at Cardiff, and is also in use at Swansea.

(*e*) *Newport.*—Much of the coal shipped at Newport is distinctly "tender," and in consequence anti-breakage boxes are greatly to the fore. The hoists are of the usual form. The loaded wagons approach the hoists on the quay level, and the empty wagons leave by an elevated road about 20 feet above the quay. Some of the hoists are operated by a single direct-acting ram under the centre of the platform. A defect of this arrangement is the difficulty of getting at the cylinder for purposes of repairs, as it is wholly below water. This difficulty has no doubt been noted, and in the newer hoists the lifting rams are placed upright, one on each side of the cradle.

The speed of loading is almost exactly the same as at Swansea.

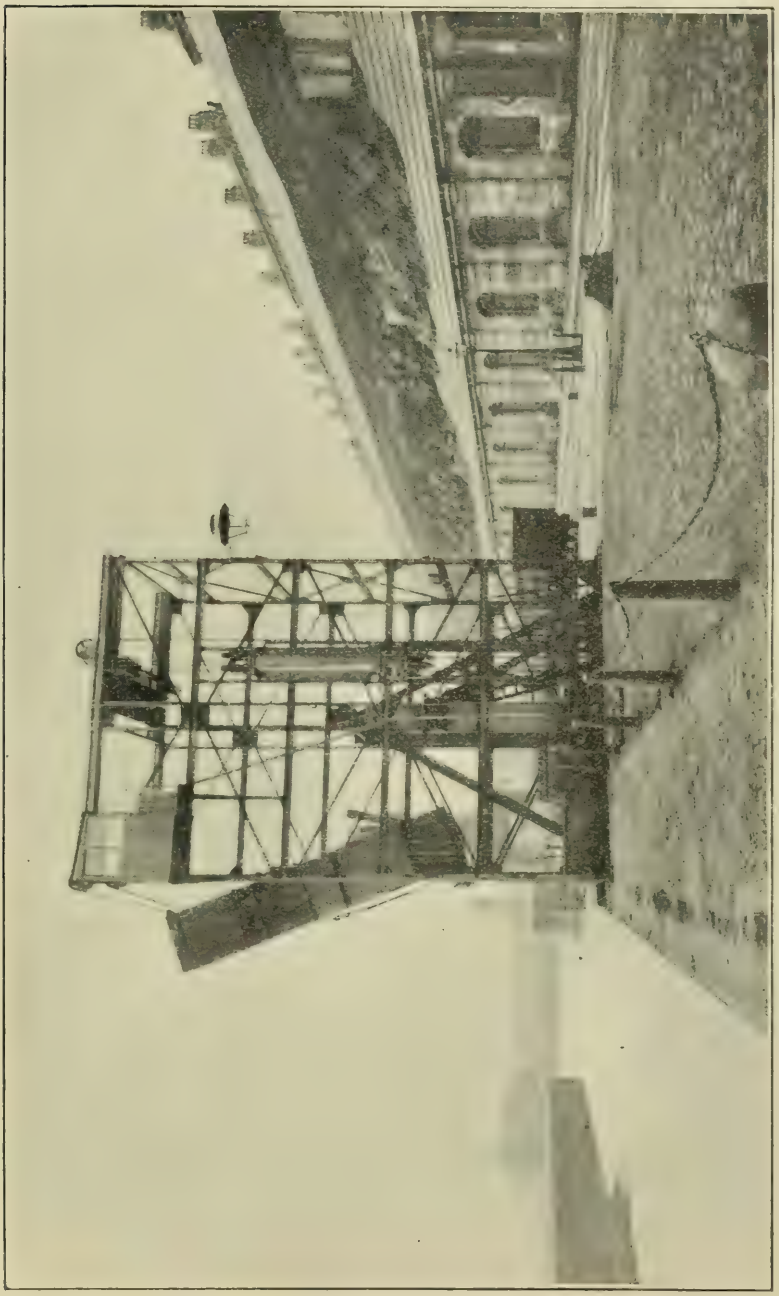


FIG. 42.—23-TON HYDRAULIC COAL-HOIST, HERCULANEUM DOCK, LIVERPOOL.

(4) *Herculaneum Dock, Liverpool.*—On the same quay containing the crane elsewhere described, there is also erected a hoist designed and constructed by Messrs. C. & A. Musker, Limited, of Liverpool, to raise a load of 23 tons (Fig. 42). The length of the platform is 23 feet; the height of the lift, 24 feet; and the cradle is lifted by two directing rams placed at each side, the rams being 9 inches in diameter.

The cradle is tipped by means of a multiplying jigger fitted with leading sheaves and wire ropes. This tip is arranged (and is chiefly employed) for tipping coal into barges of all sizes up to 460 tons burthen, at any level of water obtaining in the dock. It receives the full wagon from rails laid at right-angles to the dock-wall at the quay level, and raises it to the required height for tipping. The shoot is 26 feet long, and is fitted with doors to regulate or to stop the flow of coal, which is discharged as required.

(5) *Canada Branch Dock No. 3, Liverpool.* A powerful hoist of the direct-acting type, constructed by Messrs. Tannet Walker & Company, of Leeds, has recently been erected on the northern quay of this dock, capable of handling any wagon with cradle up to 30 tons gross weight. The hoist is movable, its range extending over 400 feet of quay; wagons approach it along railway lines parallel to the quay, and are transferred to it therefrom by means of a traverser commanding two lines of railway, and movable like the hoist. The vertical range of the hoist is 60 feet, and it can handle coal at the rate of 300 tons per hour.

(6) *Birkenhead.*—Here two hoists of the direct-acting type (Fig. 43) have been erected by Messrs. Glenfield & Kennedy, Limited, of Kilmarnock, for the Mersey Docks and Harbour Board. Each hoist is capable of raising a load of 20 tons to a height of 50 feet, and is handling about 40 wagons per hour of an average capacity of 8½ tons, equal to about 340 tons per hour. Both the full and empty wagons leave the hoist at the ground level. The wagons are raised by direct-acting rams, and are tipped into a shoot running to the hatch of the vessel. An anti-breakage box is used when commencing to load a vessel, when the fall from the end of the shoot to the bottom of the hold of the vessel is so great that the coal would be broken. The box

FIG. 43.—HYDRAULIC DIRECT-ACTING COAL-HOIST, BIRKENHEAD.

is held by the crane (which is an attachment of the hoist) immediately under the end of the shoot, and filled with coal; it is then lowered to the bottom of the vessel's hold, when the bottom is released by a hydraulic ram worked by the hoist attendant. This operation is repeated until a pyramid of coal is formed on which it is safe to run the coal from the shoots direct.

(7) *Partington Coal-basin (Manchester Ship Canal Company).*—Two hoists similar to those erected at Birkenhead are in operation here, and are doing very similar work.

(8) *Garston Docks.*—These docks are situated on the Upper Mersey, about 4 miles south-east of Liverpool, and are the property of the London and North-western Railway Company; and, as they are beyond the jurisdiction of the Mersey Docks and Harbour Board, vessels loading thereat are consequently exempt from the Liverpool dock dues. There are three docks, which cover in the aggregate an area of 28½ acres. The tonnage dealt with at the docks has grown from 295,000 tons in the year 1894 to 2,600,000 tons in 1907, chiefly from the Lancashire collieries.

Two powerful movable hydraulic hoists, constructed by the Hydraulic Engineering Company, Limited, of Chester, and capable of dealing with wagons of a gross weight of 30 tons, have been in operation at the North dock since 1906 (Fig. 44); and four more of similar type and capacity, but of increased height of lift, are in course of erection at the new Stalbridge docks recently opened. Both the loaded and the empty wagons reach and leave the hoist by the high-level railway running parallel with the dock quay, and shown in the illustration at the back of the hoists; and turntables are employed to bring the wagons end on to the hoist, ready to be run on to or off the hoist platform. The position of the fixed turntables determines the position of the hoists when in operation. The only adjustment provided between these points is by means of the shoots, which can be raised and lowered with the platform, and as they are suspended by steel-wire ropes, the outer end of each has (operated by the hydraulic winch from their noses), by means of a swivel joint arrangement, a lateral travel of 10 feet, or 5 feet on each side of its central position. Each hoist is provided with eight flanged tread wheels running on double pathway rails with

26 feet 4 inches centres, and is fitted with a hydraulic traversing engine of the well-known three-cylinder Brotherhood type. The platform is raised by four direct-acting lifting rams placed in pairs on each side of the platform, and attached at their upper ends to a cross-head, from which the platform is suspended by

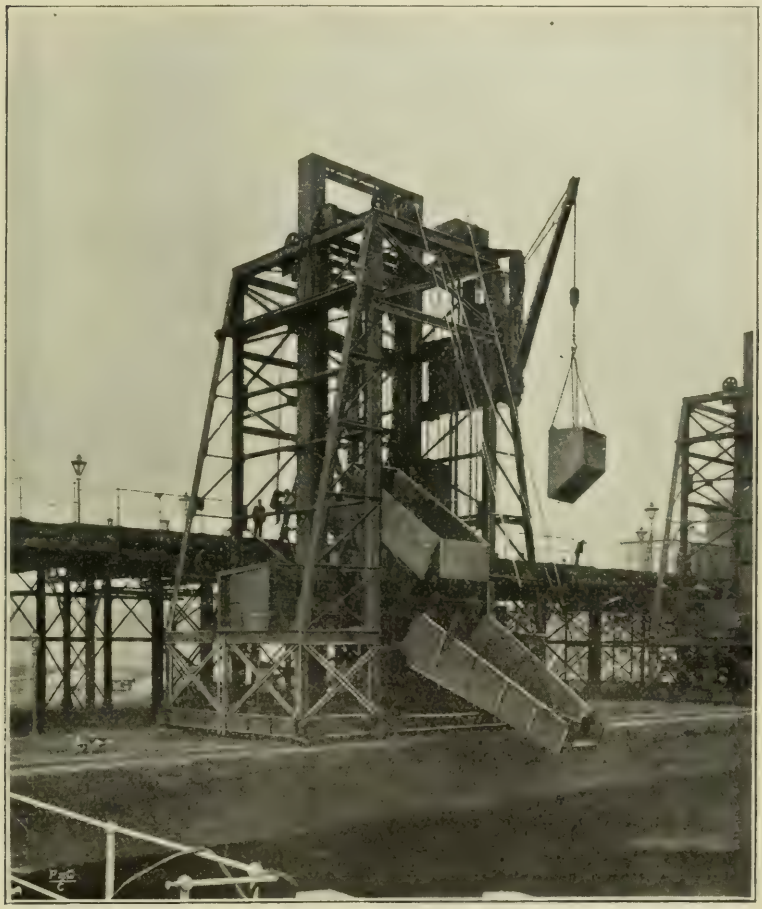


FIG. 44.—HYDRAULIC COAL-HOIST, LONDON AND NORTH WESTERN RAILWAY COMPANY, GARSTON DOCKS, NEAR LIVERPOOL.

two steel lifting-rods. These two large and two smaller rams, $9\frac{1}{8}$ inches and $6\frac{1}{2}$ inches in diameter respectively, are independently controlled by a separate set of pressure- and exhaust-valves, actuated from the controlling cabin by separate

levers. The combination of the rams for various purposes is as follows:—(*a*) With all four rams open to pressure, when ascending, the lift ascends with the loaded wagon; (*b*) with the large rams only open to pressure, when ascending, or the small ones only to exhaust, when descending, the lift ascends with the empty wagon or descends with the loaded wagon, the water from the large rams being returned to the pressure mains; (*c*) with the small rams only open to pressure, when descending, and the large ones to exhaust, the lift descends with the empty wagon, the water from the small rams being returned to the pressure mains; (*d*) with all four rams open to exhaust, when descending, the lift descends without a load. The cylinders and valve-gear are thus so arranged that the smaller or the larger cylinders can be connected to the pressure- or exhaust-mains as required, to lift or lower either the loaded or the empty wagons. When not taking pressure-water, the rams fill from a tank carried at the top of the erection, into which all four cylinders exhaust, thus operating with the greatest possible economy of pressure-water. The cradle on the platform is tipped by a hydraulic jigger carried on one side of the structure, having two steel-wire ropes, each of which is anchored at one end to the cradle and at the other to the platform, so that they travel with the platform when lifting or lowering, the cradle remaining horizontal until the jigger is put into operation, when the ropes are taken up as required to tip the cradle to the necessary angle.

The shoot in front of the tips is constructed of steel plates and bars, and is provided at its lower end with doors to regulate the delivery of the coal. These doors are worked by a small hydraulic jigger, fixed to the underside of the shoot and controlled from the cabin. The shoot is hinged to a cross-bar working between the framework of the tip, and is supported on a rack on each side, secured to the front legs of the structure.

An anti-breakage crane is carried on one corner of each tip, capable of raising 4½ tons to a height of 60 feet; it has a maximum rake of 21½ feet, with a minimum of 9 feet, and is capable of turning by hydraulic power through about 180 degrees. The whole of the machinery is operated from the valve, with the exception of that in connexion with the winch. Both tips are used for tipping coal into one vessel, so that both

fore and aft hatches can be dealt with simultaneously. Under fair conditions, one hoist can deal with thirty to thirty-five wagons per hour, and with wagons of 20 tons capacity this equals from 600 to 700 tons per hour.

The lines of rails leading to the tips and running along the high-level railway are parallel with, and at a height of from 25 to 28 feet above, the dock quays. There are four lines for each tip, one being for the return of the empty wagons. All the rails, both for full and for empty wagons, are laid on gradients so as to admit of the wagons running to and fro with a minimum of power to operate them. At the Stalbridge dock, where the approaches in the immediate vicinity of the hoists are wider and more extensive than at the North dock, the lines over which the wagons enter and leave the hoists are laid out with curves, and turntables are not required.

(9) *Poplar Docks, London.*—At these docks, which are the property of the North London Railway Company, there is in operation a hydraulic coal hoist of the suspended type, constructed by Sir W. G. Armstrong, Whitworth, & Company, Limited, Newcastle-upon-Tyne (Fig. 45). These hoists are used principally to load barges, etc., plying to and fro on the Thames, for the purposes of bunkering the large liners, and are each adapted for dealing with end-door and side-door wagons. Each hoist is capable of lifting a wagon of a gross weight of 18 tons through a height of 11 feet, and of tipping it either sideways or endways when raised to that height or to any intermediate level. The tipping frames are each mounted in trunnions attached to a steel cradle; these cradles move vertically in a steel twin framing bolted to a timber bed at the quay, and properly braced horizontally and vertically with girders overhead for carrying the lifting cylinders and tipping machinery. The tipping frame is provided with a line of rails parallel to the quay edge, and one at right-angles, the end-tip wagons being run on to the cradle at the back and the side-tip wagons at the side of the framing. The coal is tipped into a shoot, having an outreach of 5¼ feet, the shoot being of steel and capable of adjustment to suit the vessel into which coal is being delivered. Doors are provided on the shoot to control the flow of coal. The lifting cylinders for each cradle are three in number: the two outer cylinders are constantly in communication with the pressure mains, so

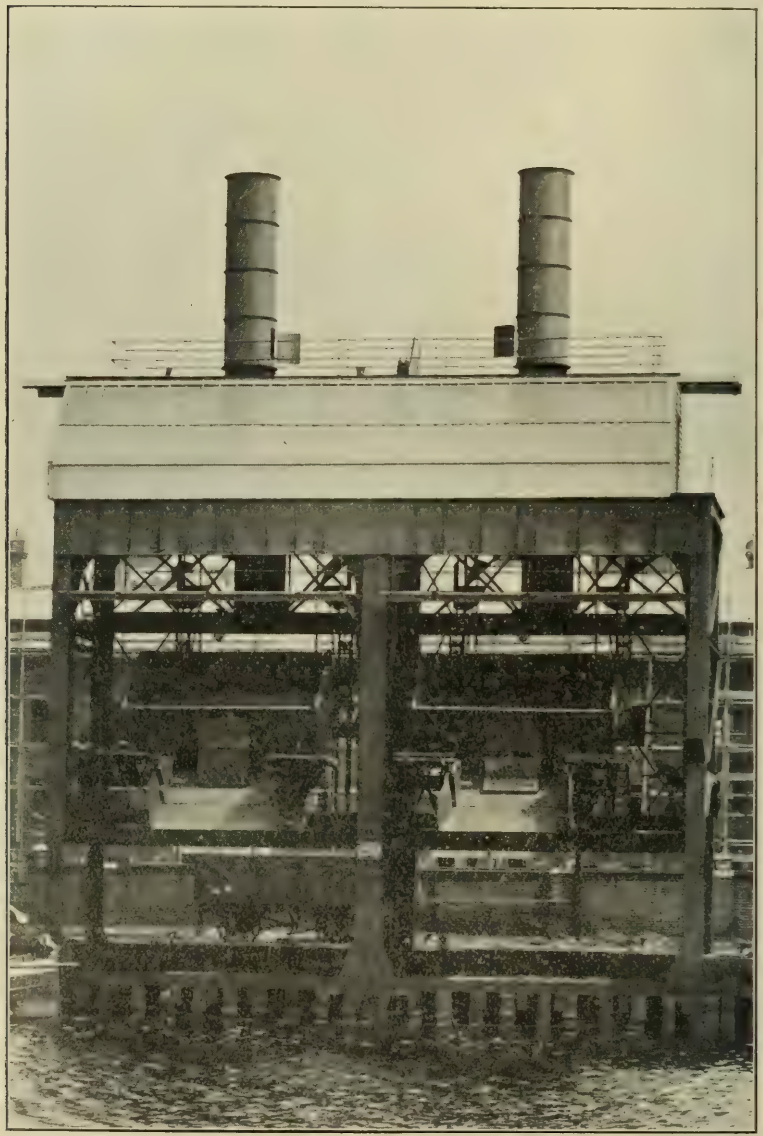


FIG. 45. – ARMSTRONG "SUSPENDED" TYPE OF COAL-HOIST (END-TIP OR SIDE-TIP WAGONS), NORTH LONDON RAILWAY COMPANY, POPLAR DOCK (THAMES).

as to balance the weight of the cradle and tipping frame, the central cylinder being that in communication with the working valves. The tipping machines for each hoist consist of a hydraulic cylinder fixed to the framing with plunger, cross-head, guide-bars, multiplying sheaves, and two chains attached

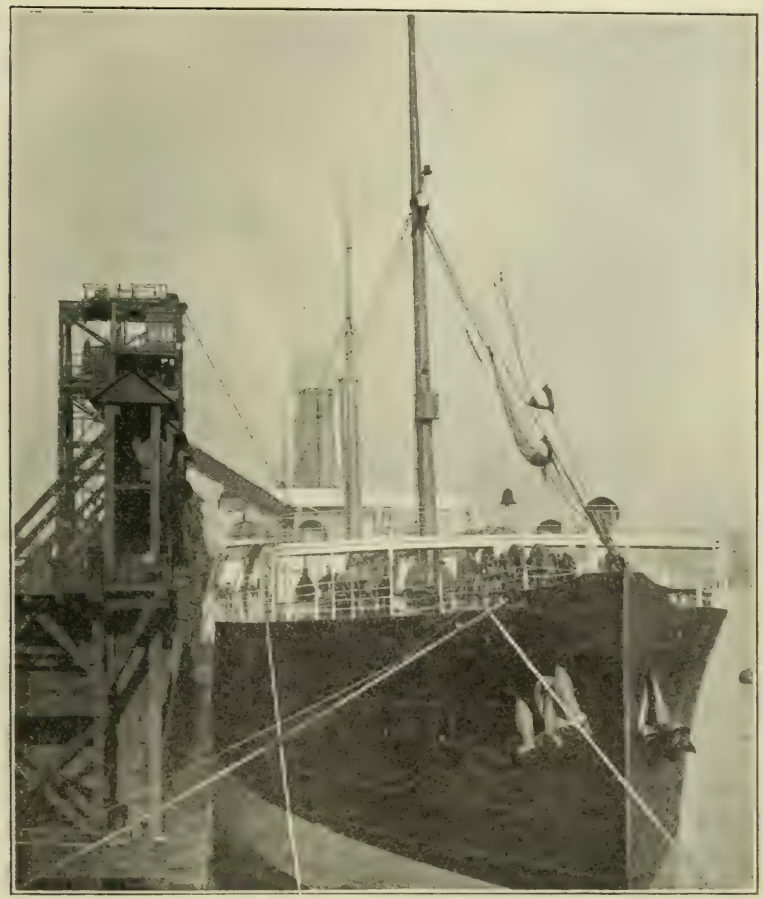


Fig. 46.—Armstrong Hydraulic Coal-hoist, Whitehill Point (Tyne).

at one end to the tipping frame, the arrangement being such that the tipping cylinder can be brought into operation and the wagon tipped at whatever level the cradle may be between its highest and lowest positions. Check chains are fitted at each end of the tipping frames, as shown in Fig. 45. The working valves for the lifting and tipping machinery of each hoist are

arranged so that they can be worked, by chains, by a man standing at one end of the cradle of that hoist. An overhead platform is provided on the cradle of each hoist with handrails, and a ladder is fitted for access to this platform from the cradle. Automatic sliding-rail stops, actuated by the hoist cradles, are provided in connexion with each hoist on the line of rails parallel to the quay edge, and double hinged stops are also fitted on each cradle.

When side-door wagons are being dealt with, the emptying of them is completed in the usual way, namely, by clearing out the corners by hand, which work is done by a man from the tipping platform, or sometimes from the wagon itself, if the coal or coke is at all wet. The wagons average 8½ tons capacity, and, when both cradles are in operation, the hoist can deal continuously with sixteen end-tip wagons per hour (136 tons), or from ten to twelve side-door wagons per hour (102 tons), the speed depending somewhat on the kind of coal, supply of wagons, barges, etc.

(10) *Whitehill Point.*—At one of the staithes worked here by the River Tyne Commission, a suspended type of hoist (Fig. 46) has been erected, constructed by Sir W. G. Armstrong, Whitworth, & Company, Limited.

(11) *Ardrossan, Clyde.*—A very small proportion of the coal exported from the Clyde and brought from the Lanarkshire coalfields is shipped from this port; in fact, it is more of an import harbour, the imports amounting to 667,415 tons for the year ending May, 1907, whereas the exports only amounted to 335,852 tons, of which 226,966 tons was coal. There are two docks and two tidal basins, but coaling operations are only conducted at the Old dock, the Eglington dock, and the Old tidal basin, the Eglington tidal basin being almost entirely used for passenger boats and boats taking general cargo. Very large vessels can be dealt with at this port. For coal-loading, direct-acting hoists are in operation, constructed by the Hydraulic Engineering Company, of Chester (Fig. 47). The hoists take the full wagons at the quay level and lift them up, and, after teeming operations are performed, the wagons leave the hoists at about 16 feet above quay level, gravitating thereto. The full roads, being at quay level, are on the level, but the inclination of the roads leading the empty wagons away from the hoists is about 1 in 50. Loading operations can be performed at the rate of one wagon per minute. End-door discharging wagons, of 10 to 16 tons capacity,

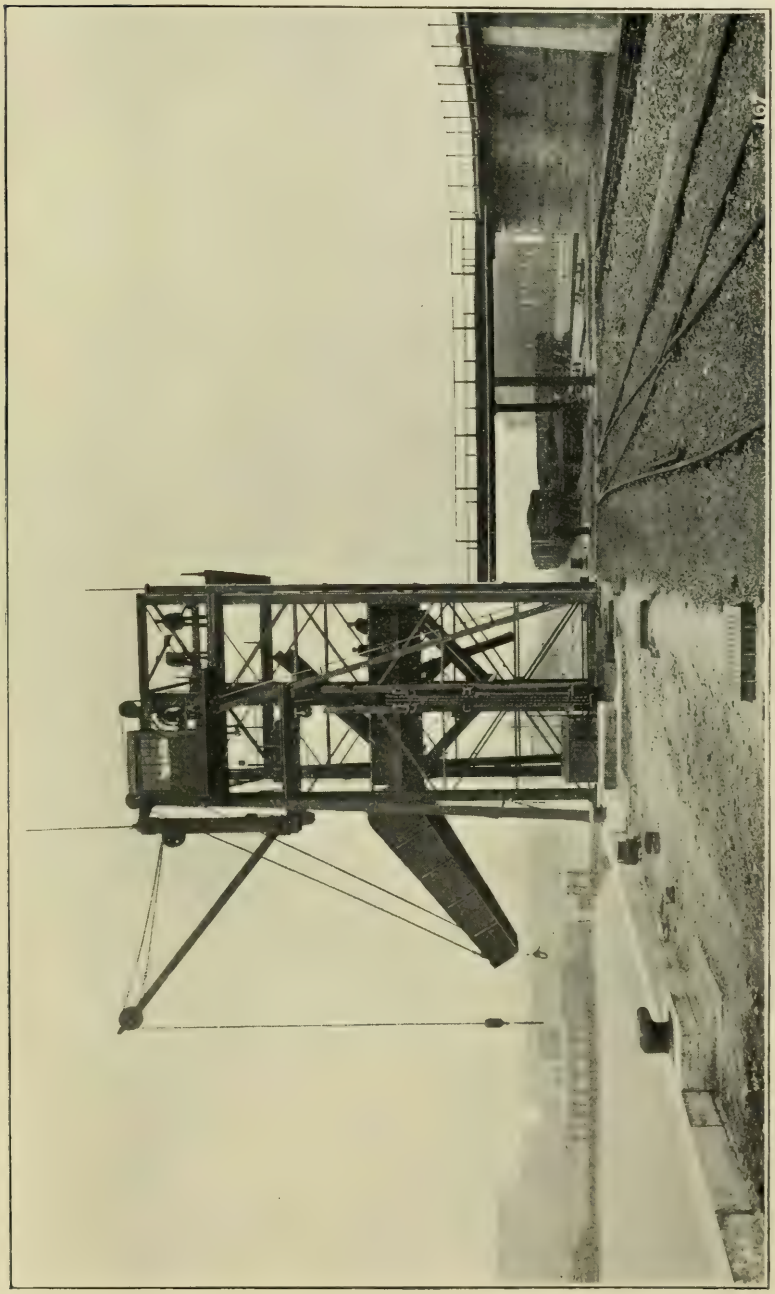


FIG. 47.—COAL-LOADING HOISTS AT ARDROSSAN (CLYDE).

are in use, which is equal to 600 to 960 tons per hour. No anti-breakage arrangement is required (owing to the nature of the coals dealt with) other than the ordinary flap-doors at the low end of the coaling shoots, although an anti-breakage crane is provided, as seen in the illustration (Fig. 47). Coaling cranes are also in operation at this port.*

Shoots.—Unlike the ordinary shoots in use in the North of England, down which the coal passes from the wagon or the hoist-cradle to the ship, an invariable feature in the form adopted throughout South Wales is a grating or screen in the bottom, through which the small coal passes, the bulk falling on the deck of the vessel during loading operations. These screenings do not go in with the cargo, but are swept up and used for a variety of purposes, not the least important of which is to raise steam in the hydraulic stations. In all the newer hoists, the shoot is provided with doors of some form or other, which enable the loading of the coal into the vessel to be stopped even when the shoot is full; they also check the speed at which the coal slides down the shoot, and so have a tendency (though probably not in a very great measure) to obviate breakage.

In connexion with the type of box shown in Fig. 27 (Plate XXXI.), there is a peculiar form of shoot. This shoot, although similar in form to those ordinarily in use, has only one instead of two doors, which is hinged on an horizontal axis. Prior to the tipping of the wagon into the shoot, this door is drawn up, hinge-framing and all, nearly to the upper end of the shoot. As the wagon is tipped, the door, etc., is lowered down the inclined plane of the shoot; and, after arriving at the bottom, the door is opened. Probably with this apparatus it is intended that the whole cargo shall be lowered into the vessel by the anti-breakage box: otherwise it would seem almost ludicrous to lower the coal so carefully down the inclination of the shoot, only to drop 40 feet after reaching its mouth.

(C) Elevator and Box.—Nil.

(D) Incline and Shoot.

Another American example is where there is a short-approach gradient of steep inclination, up which the loaded cars are propelled by means of a haulage-mule working upon a narrow-gauge track laid between the rails.

* See page 209.

(E) Cranes.

(*a*) *Fixed Cranes with Wagons:* (1) *Queen's Dock, Glasgow.*—(Described previously in No. 1, Table I.)

(2) *Ardrossan (Clyde).*—In addition to the hoists elsewhere described (page 206), coal is shipped by fixed cranes (Fig. 48), made by Messrs. Alexander Chaplin & Company, of Glasgow. The cranes receive the full wagons at quay level, lift them up, discharge them, and return them to quay level, the wagons

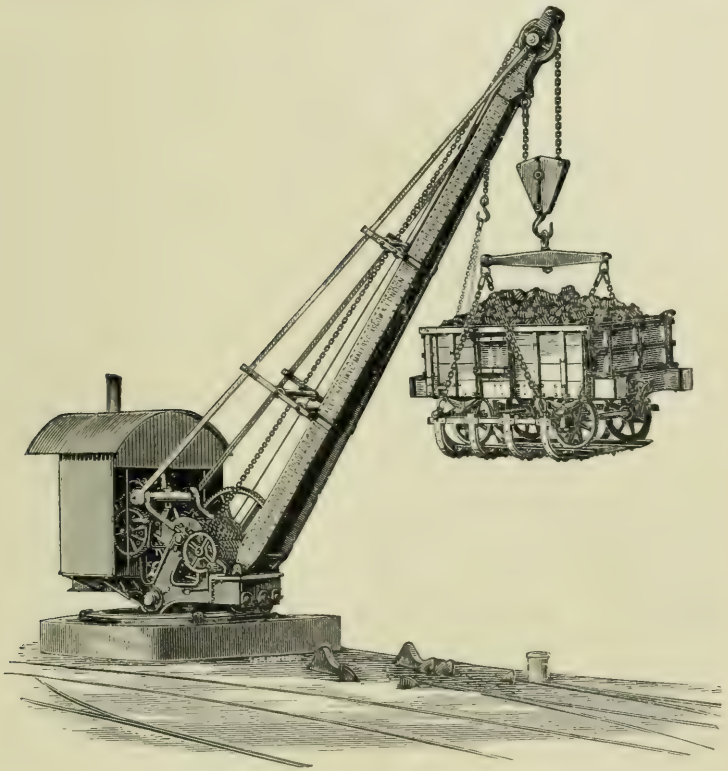


Fig. 48.—Fixed Steam Coaling Crane. Ardrossan (Clyde).

standing in a cradle, to which they are brought forward and from which they are taken away by means of rope haulage worked by hydraulic capstans.

The capacity of the wagons in use range from 10 to 16 tons. A crane can handle the wagons at the rate of one in 3 minutes, or, say, from 200 to 320 tons per hour: the speed of loading a

vessel consequently depending upon whether two or more cranes can be got to work simultaneously at the separate holds. These cranes are also extensively employed in discharging vessels or boats, the amount of tonnage discharged per hour varying to some extent according to the nature of the vessel and the wagon supply; but, under ordinary circumstances, a vessel with ore at a three-crane berth can be discharged at the rate of 100 tons per hour.

(3) *Ayr.*—The steam-crane system in use at Ayr, with 10½-ton trucks, which are fitted with end-doors, is slightly different in other respects from North-eastern Railway trucks (bottom-doors).* About 200 tons can be handled by this machine per hour.

(4) *Hull.*—In addition to the hoists described on page 188, the North-eastern Railway Company have several fixed hydraulic cranes at their various docks, as the large traffic in heavy lots of merchandise renders their use essential. Although utilized for coaling, they are not therefore primarily provided for that purpose.

These cranes were constructed by various firms in Leeds, Carlisle, and Birkenhead. Two 25-ton cranes are each capable of handling twenty-five wagons of 8½ tons capacity each per hour, equal to 212 tons per hour. Older 10-ton cranes can only handle ten to twelve wagons, equal to a maximum of 100 tons per hour. The 40-ton cranes recently erected are capable of handling eighteen wagons, equal to 150 tons per hour.

The cranes deal with both end-door and bottom-door discharging wagons. In the case of the former, the wagon can be tipped at such an angle that the coal runs out. In rare cases, where the contents of the wagon have been wet and frozen, some difficulty has been experienced in discharging them, the coal coming out in large quantities as solid lumps. In the case of bottom-discharge wagons, when the contents are similarly bad, the men have to use crow-bars on the top and at the open bottom doors in order to get the coal to run.

(b) Travelling Cranes with Wagons: (1) *Herculaneum Dock, Liverpool.*—On the east quay of this dock there are two movable hydraulic cranes of 30 and 25 tons power respectively, the former designed and constructed by Sir W. G. Armstrong, Whitworth,

* *Trans. Inst. M. E.*, 1898, vol. xv., plate iv., figs. 2 and 3.

& Company, Limited, and the latter constructed by the Hydraulic Engineering Company of Chester (Fig. 49). These cranes are capable of dealing with wagons of the largest size at any distance from the face of the dock-wall not exceeding 30¼ feet, and lift,

Fig. 49.—25-ton Movable Coaling Crane, Herculaneum Dock, Liverpool.

swing, and luff. They travel and tip, at the highest speeds consistent with safety, on two rails laid at the quay level. The distance, centre to centre, of the rails is 23¼ feet, and the pedestal of the crane is arched in a form which allows of the wagons pass-

ing through it. Lines of rails with all the necessary capstans, cross-overs, etc., for the handling of full or empty wagons are laid on the quay, and are in direct connexion with the adjoining goods station.

The crane, designed and constructed by the Hydraulic Engineering Company, Limited, has a maximum rake of 41 feet 7 inches, and can be luffed in through a range of 20 feet. It is capable of lifting loads of 25 tons through a height of 50 feet, and can be slewed through a complete revolution. The height to the top of the mast is 71 feet from the rail-level; and to the centre of the jib-head sheave-pin at the maximum and minimum rakes it is 63 feet and 78½ feet respectively.

The structure, supported on four double-trod wheels, runs by means of a Brotherhood three-cylinder hydraulic engine and spur gearing on rails arranged in pairs. The pedestal of the crane is of pyramidal form, nearly square at the base, and arched to a sufficient height to allow of a locomotive passing underneath. The mast, composed of two heavy plate girders, having the main lifting cylinder bolted between them, revolves in a brass-lined toe-step, and is steadied by a live roller-ring supported by the pedestal. A direct-acting luffing cylinder is carried on cast-steel trunnions at the top of the mast; while at the back are attached the inclined girders carrying the cradle tipping jigger and the two cylinders for slewing the crane, the latter being bolted on the outsides and the former centrally between. The wagon cradle on which the trucks are lifted is so constructed that either end-tipping or hopper wagons may be discharged; it is approached by short ramps attached to the cradle, which is guided into position on the rails by movable cast-steel guides placed at any convenient point; no pit is required, nor is there any break in the continuity of the railway. The cradle is slung by four chains from a cross-head attached to the anti-friction roller-bearing swivel at the ends of the double lifting chains. The swivel allows of a man easily turning the cradle and loaded wagon in mid-air by means of a rope.

The tipping is effected by two additional chains made fast to the rear end of the cradle, and carried over sheaves in the overhead beam, where they are connected by a swivel attachment to a single tipping chain working through the centre of the main lifting-chain swivel and passing over the jib-head to the tipping

cylinder at the back of the mast. The tipping cylinder is constructed in two parts, having rams of different diameters, and placed end to end; water is admitted to the smaller one simultaneously with the main lifting cylinder, the slack of the tipping chain thus being taken up. The larger one is brought into action when the wagon is over the hatchway; the smaller ram is meanwhile kept in its outward position by the intensified pressure of the water in its cylinder.

Whilst being tipped, the truck is held on the cradle by movable stops engaging with the front axle, and the other end is secured by attaching the draw-chain to an anchor hook. A truck may be run on and off at either end by means of hydraulic capstans, but the usual method is to draw it over the cradle until the leading axle comes into contact with the stops, and then to secure the draw-chain at the back. The whole is then lifted, slewed over the vessel, and an attendant brings the door of the wagon into position for tipping into the hatchway by turning the cradle on the anti-friction swivel. When the wagon is discharged, the crane lowers the cradle between the guides, which ensures its coming down into correct position with regard to the rails.

The length of the sling chains is so adjusted that the stop or front end comes first in contact with the rails in lowering, thus starting the truck backward from the stops. These are lowered to allow the axles to pass over them by operating a lever placed in a safe position at the side of the cradle. Another loaded truck is now drawn on the cradle, pushing off the empty one before it, its own progress being arrested by the stops, which meanwhile, on the lever being released after the passage of the empty truck, have been returned to their upright position by springs. The tipping operation is repeated, and the process continues.

Should it be desired to draw the wagons on at the front of the cradle, the contour of the stops is so made that they are automatically depressed by the axles of the truck passing over in this direction, and immediately spring back to their upright position when it is on the cradle.

When it is required to move along the dock side, the guides are coupled to the cradle by means of links specially provided, and the whole is lifted by the crane and carried to the desired point, when the guides are again secured to the rails laid inside

the crane tracks for this purpose. The crane is thus able to work in any position along the length of the quay.

With a view to enabling the crane to be also used for shipping machinery, boilers, and other heavy work, a large shackle is attached to the lower part of the lifting-chain swivel, and the cradle is made easily detachable from the overhead beam.

The connexions with the pressure hydrants are made both by a walking pipe and by an armoured hose. The latter is used while traversing and the former is coupled up when the crane is alongside of the vessel to be loaded. The working pressure is 780 pounds per square inch.

This appliance is capable of shipping from thirty to forty wagon-loads of coal per hour (each wagon containing from 8 to 10 tons), equal to 320 to 400 tons per hour.

(2) *Birkenhead.*—Here the arrangements are of an entirely different character. The railway approaches the docks on the quay level, and, consequently, before coal can be shipped direct into vessels of any size, it has to be lifted a considerable height. This is done by means of hydraulic hoists set on the edge of the quay. There are three fixed hoists, two of which are each capable of lifting full-sized wagons through a height of about 50 feet, and there tipping them. The third is for a smaller class of vessel, and has not so great a stroke. There is a fourth hoist, which is movable and of special construction, so as to allow of its being fed, not by end-on railway lines, as is usual, but from lines running fore and aft along the quay. This is so contrived that the hoist may not merely be used at certain fixed positions, but at any desired position to suit the hatches of vessels, and so arranged that wagons can run through it without obstruction, so as to feed another hoist should the increasing demands for rapid shipment require that addition. The requirements as to height and as to lines of rails passing through it make the hoist a high and wide structure, the height being 75 feet and the width 40 feet. All the operations are effected by hydraulic power, actuating chains worked over multiplying sheaves in the ordinary manner. The speed at which coal can be shipped at this hoist depends, of course, as in many other cases, on the arrangements for trimming the coal in the holds, but with suitable steamers a very rapid rate can be obtained.

Another feature has recently been added to the coal accom-

modation at Birkenhead by the erection of a special coaling jetty in the East Float, having on it four portable hydraulic cranes of 54 tons power each. These are used to transfer bunker coal from the South Wales colliers lying on one side of the jetty to flats or lighters lying on the other side. Vessels of the latter class are largely used on the Mersey for conveying coal from the hoists, tips, or cranes, to the ocean-going steamers, which cannot go to the appliances without loss of valuable time. The flats are therefore used to go alongside the steamers at their berths, thus enabling cargo and coal to be taken in at the same time.

(3) *Harton Low (New) Staithes, South Shields.*—Land and 618 feet of river frontage on the Tyne are owned by the Harton Coal Company, Limited, and are used as private shipping staithes. A tunnel beneath the street connects the staithes with the company's own private railways from their collieries, and thus dispenses with the necessity and expense of the North-eastern Railway Company handling such outputs to their Tyne Dock staithes. Two movable cranes (Fig. 50), constructed by Messrs. Russell & Company, Motherwell, Glasgow, are in operation, each having a lifting capacity of 25 tons and being capable of dealing with either 4-ton wagons or 10-ton trucks. The jib has a radius of between 25 feet and 35 feet. The lifting speed is 60 feet per minute, and a complete revolution can be made in 30 seconds. The hoisting power is obtained from a pair of cylinders 16 inches in diameter by 20-inch stroke, the slewing power from two cylinders 8 inches in diameter by 12-inch stroke, the propelling power from two cylinders 8 inches in diameter by 12-inch stroke, and the derricking (hydraulic) power from one cylinder 15 inches in diameter by 4½-foot stroke. The pumps supplying the hydraulic power for derricking are fitted with cylinders 5¼ inches in diameter by 20-inch stroke, and are worked from the tail-rods of the main hoisting engine. The vertical boilers are 21½ feet long by 6 feet in diameter, and contain five cross-tubes, each 15 inches in diameter. The whole structure is supported on framework capable of allowing wagons to pass underneath it. The wheel-base measures 38½ feet, each set of wheels running between a pair of rails. The cradle lifts 34 feet above quay level. One crane can handle sixty-five 4-ton boxes per hour (equal

to 260 tons), but the two can be moved so as to work simultaneously into one vessel. With 10-ton wagons, this quantity can be increased to 300 tons per hour. These cranes are superior to the old-fashioned drop system for the shipping of coal, owing to their being able to lower the wagon nearer to the top of the hatchway. There are three full lines branching off from a single track at the end of the tunnel, the grade of the full roads on to the staithe head dipping 1 in 40, then 1 in 60 down the staithe to a short length of curve laid at 1 in 20, and terminating on to a self-acting turntable, whence a short length of empty road dips 1 in 45 on to a continuous-running endless-chain elevator capable of raising four empty wagons on the incline simultaneously. The road after reaching the summit falls 1 in 55, and the latter half 1 in 72 to the bottom of the empty bay, from which point the wagons are hauled by locomotive power, the track rising 1 in 75 and lastly 1 in 80 to the points at the mouth of the tunnel.

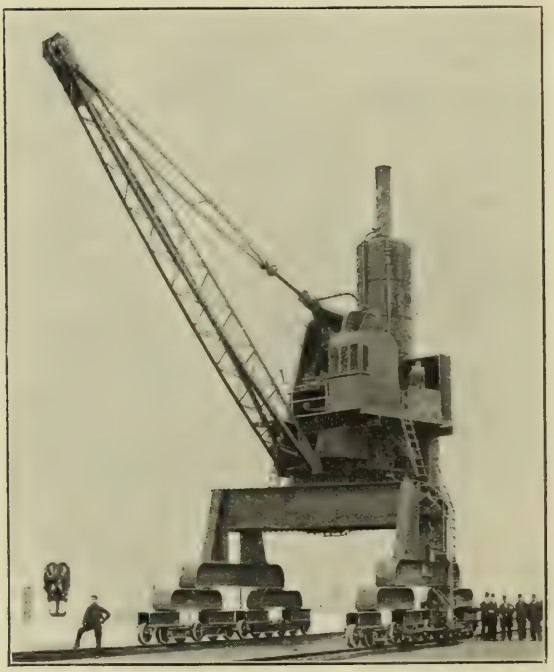


Fig. 50.—Russell Coaling Crane, Harton Coal Company's (Low) New Staithes (Tyne).

(4) *Cessnock Dock, Glasgow.*—A crane of the movable locomotive steam-coaling type (Fig. 51) has recently been erected at this dock for the owners of the Allan Line, Limited, and was constructed by Messrs. Alexander Chaplin & Company, of Glasgow. It has a curved jib, so as to clear the side of their largest vessel;

the radius is 36 feet, and the gauge 12 feet; and it has been tested with a load of 23 tons. The height of the centre of the jib pulley is 51 feet above the quay level, and it is claimed to be one of the largest and most powerful cranes of the kind yet constructed. The different motions of hoisting, slewing round, and travelling, have each a separate set of double-cylinder engines,

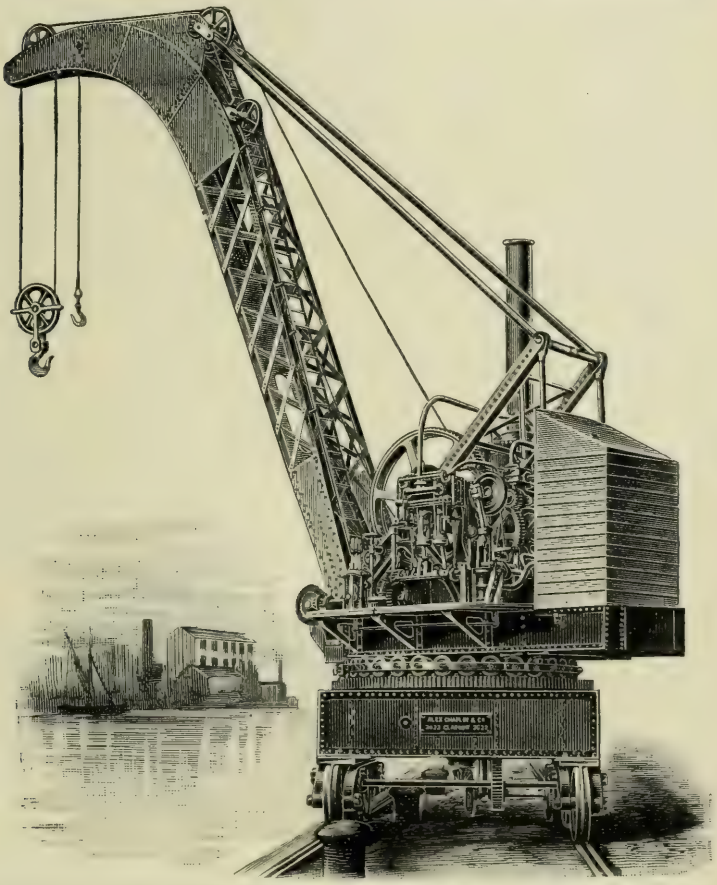


FIG. 51.—20-TON SELF-PROPELLING STEAM CRANE, NEW CESSNOCK DOCK, GLASGOW.

thus avoiding a complication of gearing and clutches. Steel-wire ropes are also used instead of chains, and the working is thus easy, and as nearly noiseless as possible. As a great part of the work of the crane is the coaling of steamers, for this purpose a second hoisting barrel is fitted, and used for tipping up the ends

of the wagons. This barrel may also be employed for working light lifts when the crane is not used for coaling. Steam is supplied from one vertical boiler, having cross tubes in the fire-box. As the rail access is contracted, the crane has never been able to be worked up to its full capacity when bunkering steamers.

(*c*) *Fixed Cranes with Boxes, Buckets or Skips.—Nil.*

(*d*) *Travelling Cranes with Boxes, Buckets or Skips: Bute docks, Cardiff* (see description of the Lewis-Hunter anti-breakage crane under Anti-breakage Appliances, page 241).—There are eleven cranes on the side of the Roath Dock working on the above principle; and, as they are made to travel along a road parallel to the coping, as many cranes can be got to work on a vessel as there are hatches, and the load can be dropped at any point of the hatch, thus reducing trimming to a minimum, and also saving the moving of the vessel during loading operations.

The speed of loading by the use of these boxes is about the same as that of the direct shoot, namely, 350 tons per hour per crane as a maximum: there being practically no difference in the time taken to teem a 10-ton wagon as against a smaller size. There is a turn-out road close to the hoists, so that the empty wagons can be shunted on to their proper line, the time for the round trip taking about 3 minutes on an average.

III.—Aerial Ropeways and Hoppers and Shoots.

Shipping Coal by the Aerial Wire-rope System at the Gowrie & Block House Colliery Company's Wharf, Port Morien, Cape Breton.—As the designer of this system, Mr. Roe, of Ropeways, Limited, London, claims that it is easily installed, economical in working, simple in operation, easily maintained when erected, and is adapted for almost any practical working condition; and, for the tons of material which it is capable of handling, the first cost is very small compared with the usual means of transportation. It may be of interest to give an extract of a paper written by Mr. Jos. G. S. Hudson, M.E., and published in the *Journal of the Canadian Mining Institute*,* on a system laid down by the Gowrie & Block House Collieries, Limited, for the shipment of their coal. A wharf for the purpose, built by the customary means of the district, and similar

* 1901, vol. iv., page 131.

to the neighbouring pier of the Dominion Coal Company, was estimated to cost at least £5,000: on the basis of a length of 1,000 feet to such a point as to get a minimum depth of water at low tide, from which point the wharf would have to be extended sufficiently for ocean steamers to load. Consequently, the wharf was built 1,000 feet from the shore (Fig. 52), and the loading-station at the pit-mouth and screens 200 feet further away (Fig. 53), the support towers between each end being spaced from 325 to 375 feet apart (Fig. 54).

At the loading station is placed a small Jencker engine,

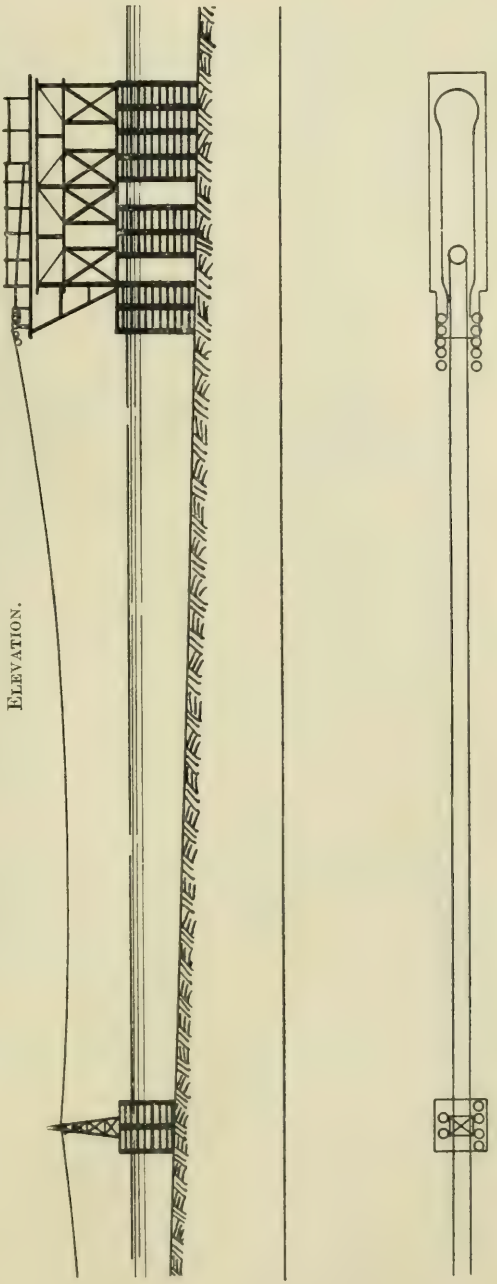


Fig. 52.—Elevation and Plan of Receiving Station on Pier (Aërial Ropeway), at the Gowrie and Block House Colliery Company's Wharf, Port Morien, Cape Breton, Nova Scotia.

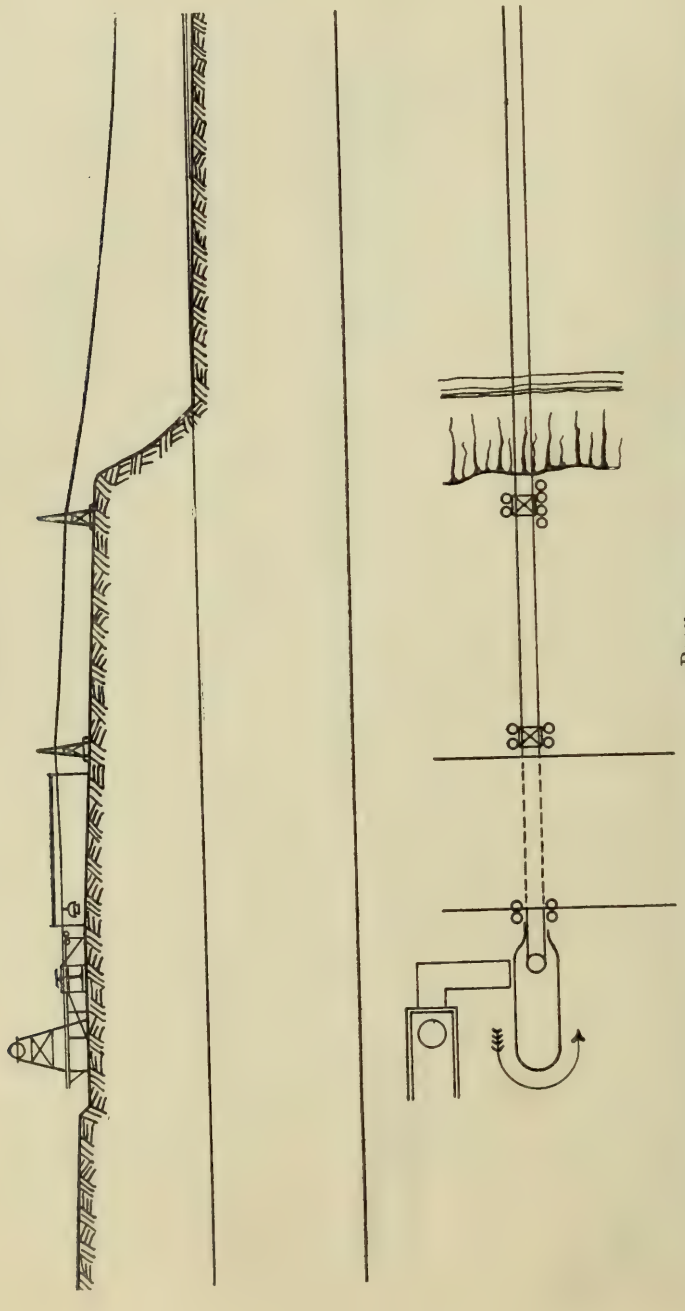


Fig. 53.—Elevation and Plan of Loading Station (Aërial Ropeway) at the Gowrie and Block House Colliery Company's Wharf, Port Morien, Cape Breton, Nova Scotia.

with cylinders 9 inches in diameter by 12-inch stroke, driving a fly-wheel 42 inches in diameter, off which a four-ply 8-inch rubber belt on a 42-inch Dodge split-pulley drove a 2-inch shaft to a geared bevel-wheel 5 feet in diameter, placed horizontally on a 6-inch perpendicular shaft immediately above the rope-wheel, $7\frac{1}{2}$ feet in diameter. The driving-shafts make 14 revolutions per minute. The rope is $1\frac{1}{8}$ inches in diameter, and of ordinary Lang lay.

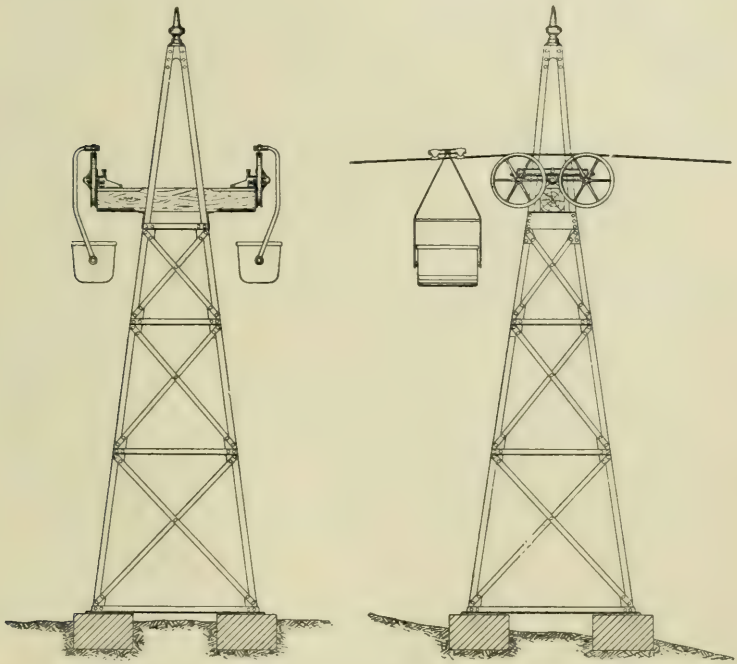


FIG. 54.—VIEW OF TRESTLES, FITTED UP WITH BALANCE-SHEAVE GROUPING FOR DISTRIBUTING ROPE PRESSURE, AND ROPEWAY CARRYING MINERAL BUCKETS.

The driving-wheel is placed at the near end of the loading station (Fig. 55), so that the shunt-rail is extended farther than the loading point, thus allowing sufficient room for the empty buckets to stand on the shunt-rail and to radiate to the loading point, and give sufficient standage room between the empty and the full buckets. The terminal stations (Fig. 56) are built of $4\frac{1}{2}$ by 9-inch scantling uprights in concrete foot-blocks. The bents are of 9 feet centres and $7\frac{1}{2}$ feet high, on which is suspended by cast-iron hangers a piece of steel $3\frac{1}{2}$ inches deep by $\frac{3}{4}$ inch thick

(Fig 57). These pieces form the shunt-rail. The carrier is so designed that it forms a clip on the rope, and is also provided with two wheels, 6 inches in diameter (Fig. 58), which come into operation when the buckets leave the rope at the terminal points, and are transmitted with the rope's impetus to the shunt-rail, both at the loading and unloading stations. The buckets are of pressed steel, carry 850 pounds, and are distributed 200 feet apart.

The operator simply gives the loaded or empty bucket a shove, the wheels on the carrier running along the shunt-rail until they reach the moving rope, which then conveys the bucket onward.

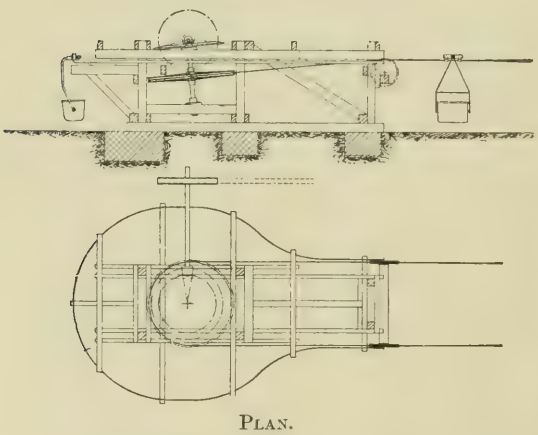


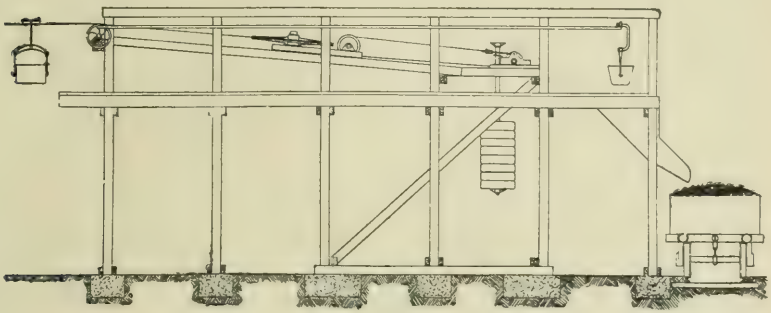
Fig. 55.—Elevation and Plan of Driving Station.

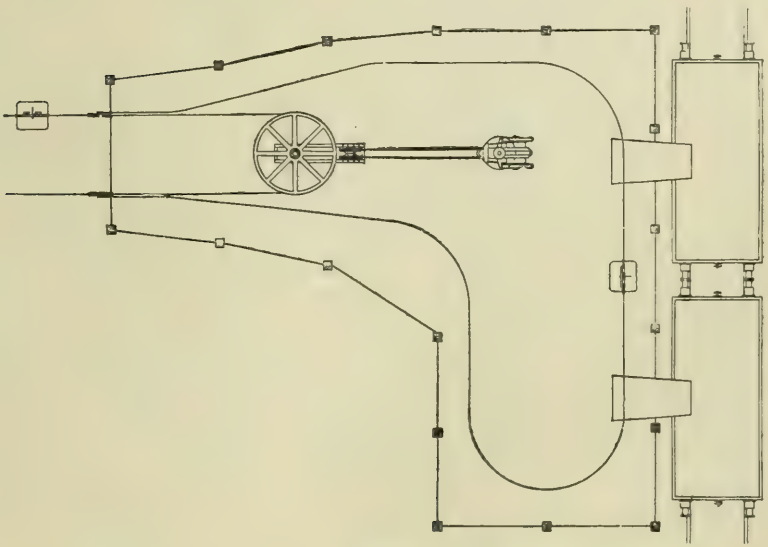
One hundred feet from the loading station is a tower 11 feet high, with a cross-arm of sufficient length to spread the rope apart, and thus prevent the full buckets from meeting the empty ones (Fig. 54), and on these towers are suspended, by means of self-moving bracket-arms, four wheels in line on the full side, and two wheels on the empty side, so balanced that they dip down to accommodate themselves to an even distribution of rope pressure due to the varying position of the buckets. They also divide the angle of the rope passing over a trestle, causing less bending and consequently less wear.

At the pier (Fig 56) a platform projects from its end, on which are a series of receiving-wheels in front of the shunt-rail. After the loaded bucket arrives, the man operating the pier-end runs it along the shunt-rail until it reaches the place over the hopper where he wishes to tipple it, when he lifts the latch; the bucket on the gudgeon dips over, and returns; he

then closes the latch, and runs it around the radial end of the shunt-rail, until it is caught by the rope and carried back to the loading station.

ELEVATION.





PLAN.

FIG. 56.—ELEVATION AND PLAN OF TENSION AND DISCHARGING STATION.

The tension on the ropes is obtained with a 3-ton weight acting through multiple gear, giving a constant effective pull of 6 tons on each side of the cable. The gear consists of a long vertical worm-rack, on to which the weight is hung, and which engages with a corresponding worm-wheel fitted to the drums

of a capstan, the arrangement automatically taking up or allowing for variations in the length of the rope due to temperature, etc. The coal is weighed in buckets by a Fairbanks scale, suspended on a section of the shunt-rail.

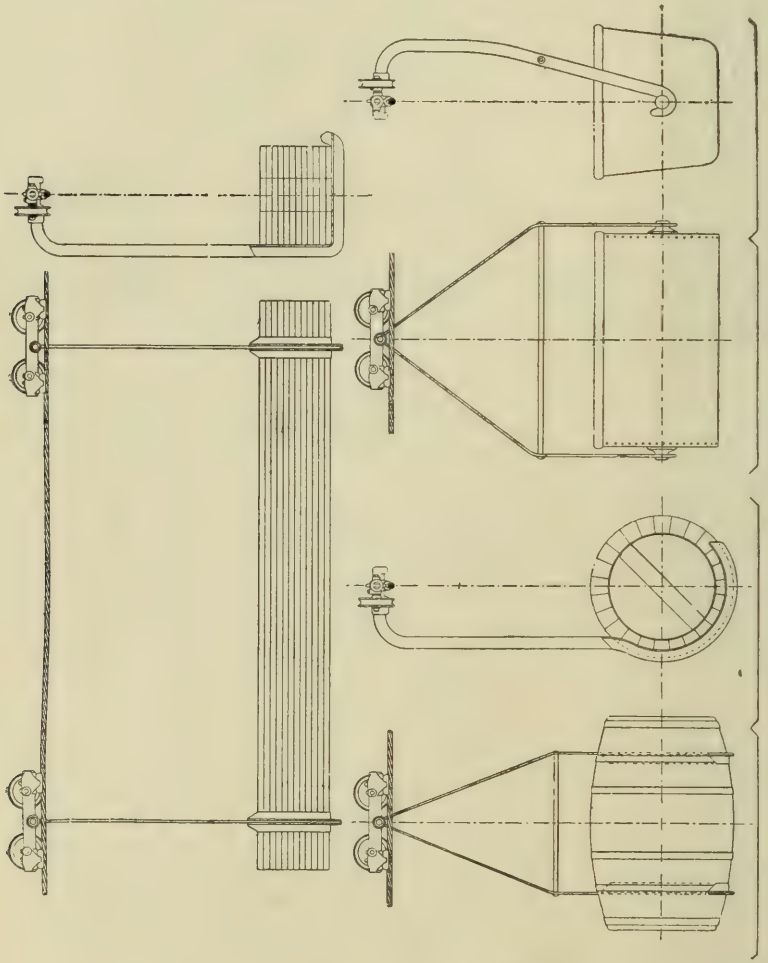


FIG. 57.—CARRIER AND MINERAL BUCKETS AND STORE BARRELS.

The system is operated by two men and a small boy, the latter to watch the engine in case of any accident occurring, or to avoid an uneven distribution of the buckets (the rope having a tendency to race if the loaded rope gets too many loaded buckets placed on it in a short space).

The capacity of the system guaranteed by the makers was

50 tons per hour, but apparatus can be erected to deal with a capacity of four times that quantity, or 200 tons per hour.

When deciding to employ this system, it is advisable to lay out the plant for the full maximum of work at the outset, otherwise it is found to be cheaper to duplicate the plant than to pull out the original installation and lay down a heavier plant to carry twice the load. Several conditions must be taken into account, as it is not a question of merely duplicating the number of buckets working on the top. For the successful working of the system, it is essential that the buckets should be hung on and spaced at regular distances apart on the rope, such distances to be fixed as calculated by the maximum weight which the rope or supports are capable of carrying.

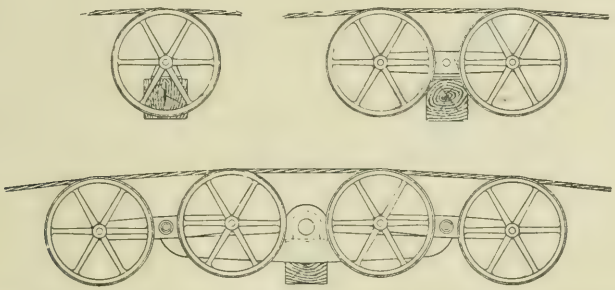


FIG. 58.—BALANCE-SHEAVE GROUPING FOR DISTRIBUTING ROPE PRESSURE.

The pier was designed as follows:—The first 100 feet to contain four hoppers of 90 tons capacity each, for loading schooners with a draught up to 14 feet at low tide; 200 feet of pier has recently been built for the steamer section, which is to have a storage capacity of 800 tons, there being from 18 to 20 feet of water at low tide along this section, plus 4 feet for high tide.

Owing to the heavy gales experienced on the Cape Breton coast, considerable trouble was anticipated, the buckets possibly swinging on the ropes and catching each other, or striking against the support towers; but, even in the heaviest gales, they have never given any trouble, and the whole system has realized the fullest expectations.

From the preceding, it will be seen that although the system possesses certain advantages in the cost of its installation, yet it necessitates the cost of building adequate bunkers at the

point of loading, from which teeming or other operations must be conducted, as it is too slow in itself for sufficiently speedy loading facilities. The coal must also be a good deal broken up in the course of its operations.

IV.—Anti-Breakage Appliances.

(*a*) *North Country.*—Reviewing the question of appliances for the avoidance of breakage in the shipment of coal in the North of England, it may be of interest to many of the members to know that contrivances were in operation on the north side of the Tyne as far back as 1870, the coal being lowered from the end of the hanging spout into the vessel's hatchways by a bucket of from 2 to 3 tons capacity, operated by means of a chain passed round a pulley, and, when empty, coming close up under the end of the spout. This arrangement, however, was not altogether satisfactory from a working point of view, inasmuch as the drop from the end of the spout to the bottom of the bucket was considerable, and there was also a tendency to release the doors in its downward journey, before reaching the coal already in the hatchway.

In 1883, the North of England United Coal Trade Association commissioned Mr. Percy G. Westmacott to draw up a report on the question of the shipment of coal, with the view of suggesting some means of lessening the serious amount of breakage which then took place in transferring the coal from railway trucks into the holds of vessels. A summary of this report is given by the writer, as follows:—

Of the two classes of staithes (balance and shoot), it may be said broadly that the balance staithes admit of less breakage of coal on the whole, and that the shoot staithes are capable of shipping larger quantities in a given time, but the defects of the latter are:—

(1) The heavy amount of breakage caused by excessive fall of coal from the bottom of the truck upon the receiving hoppers.

(2) The generally defective construction of the receiving hoppers, which, with their angles and sharp turns, break the coal unnecessarily.

(3) The fall from point to point along the line of shoots.

(4) The tapering inward of the shoots.

(5) The absence of proper arrangements for controlling the continous flow of coal down the shoots, which ought always to be full of coal.

After studying various kinds of arrangements, Mr. Westmacott presented the following suggestions:—

(1) Any plan adopted should be based upon the gravitation system.

(2) The most desirable (owing to the large amount of capital laid out in the then existing arrangements) should interfere as little as possible with the present structures.

(3) The desirability, if possible, of constructing such a plan as should be applicable to all kinds of then existing staithes.

(4) That coal was not materially injured, if allowed to gravitate in a continuous unbroken mass through a smooth shoot or spout tapering slightly outwards and having no obstructions, sharp corners, or angles.

(5) He considered that the best form to adopt was a cylindrical hopper capable of being extended from the receiving hopper on the rail level in an unbroken form right down to the bottom of the hold of a vessel, and so constructed as to be readily shortened as the body of coal rises in the vessel; and, as it would not be possible in all cases to make the spout of a straight form, the bends, where necessary, should be rounded to a good radius.

(6) The spouts should be made to swing sideways, and might be carried by means of a jib or derrick, or some simple contrivance.

Although no satisfactory invention originated from this report at the time, it doubtless had the useful effect of stimulating inventors to work upon the proper lines.

(*b*) *The Wrightson Coal-shipper:* (1) *Cramlington Coal Company's Staithes, Howdon Dock (Tyne).*—This coal-shipper (Figs. 59, 60, and 61) has already been described by Mr. John Morison.* The quantity which can be removed by the present machine has been found to be a 4-ton wagon in 30 seconds, or at the rate of 480 tons per hour. With a broader belt, and a greater depth of coal, both of which are practicable, there would be no difficulty in removing even larger quantities; but, owing to existing conditions, at present only 300 tons per hour can be run down the

* *Trans. Inst. M. E.*, 1898, vol. xv., page 67.

incline. Had, however, 10-ton wagons been used instead of those of only 4 tons capacity, the quantity of coal dealt with would have amounted to 1,200 tons per hour.

FIG. 59.—WRIGHTSON COAL-SHIPPER (1899), CRAMLINGTON COAL COMPANY'S STAITHE, HOWDON DOCK.

The truck or wagon, after being brought on to the staithe head, is first discharged into a small hopper immediately below

the truck, from the bottom of which the coal is carried by an endless horizontal belt along to the quay edge, and there transferred

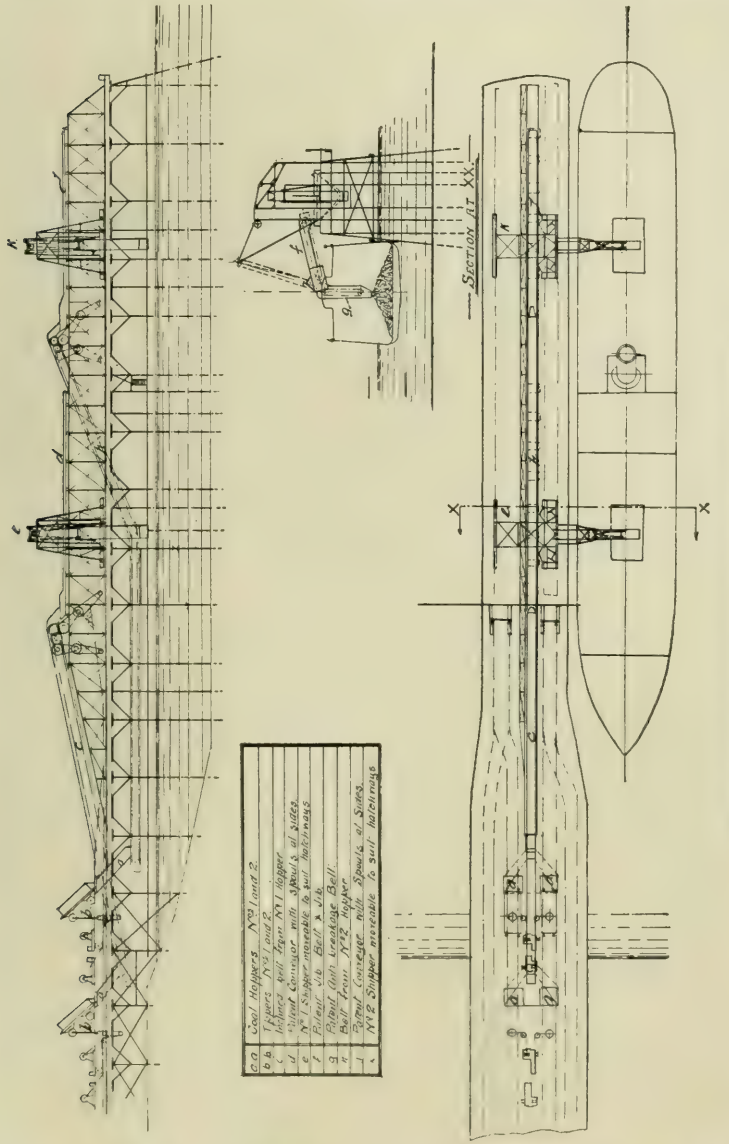

SECTION AT XX
Coal Hoppers No 1 and 2.
Jigger No 1 and 2.
Hinged Belt Elev. No 1 Hopper
Travel Conveyor with Spouts at Sides.
No 2 Elevator Belt to suit Waterways
Patent Anti Breakage Belt.
Patent Anti Breakage Belt.
Belt Elev. No 2 Hopper
Travel Conveyor with Spouts at Sides.
No 2 Shipper moveable to suit Waterways

FIG. 60.—COALING PLANT, WITH WRIGHTSON PATENT ANTI-BREAKAGE FILLERS, ALEXANDRA DOCK, GRIMSBY (1907).

on to a second or jib-belt. The frame carrying this belt is hinged at the shore end, so that it can rise and fall at its outer end to suit the rise and fall of the ship. It has also a slewing

motion right and left, to enable the coal to be directed along the second belt towards any portion of the hatch, in order to

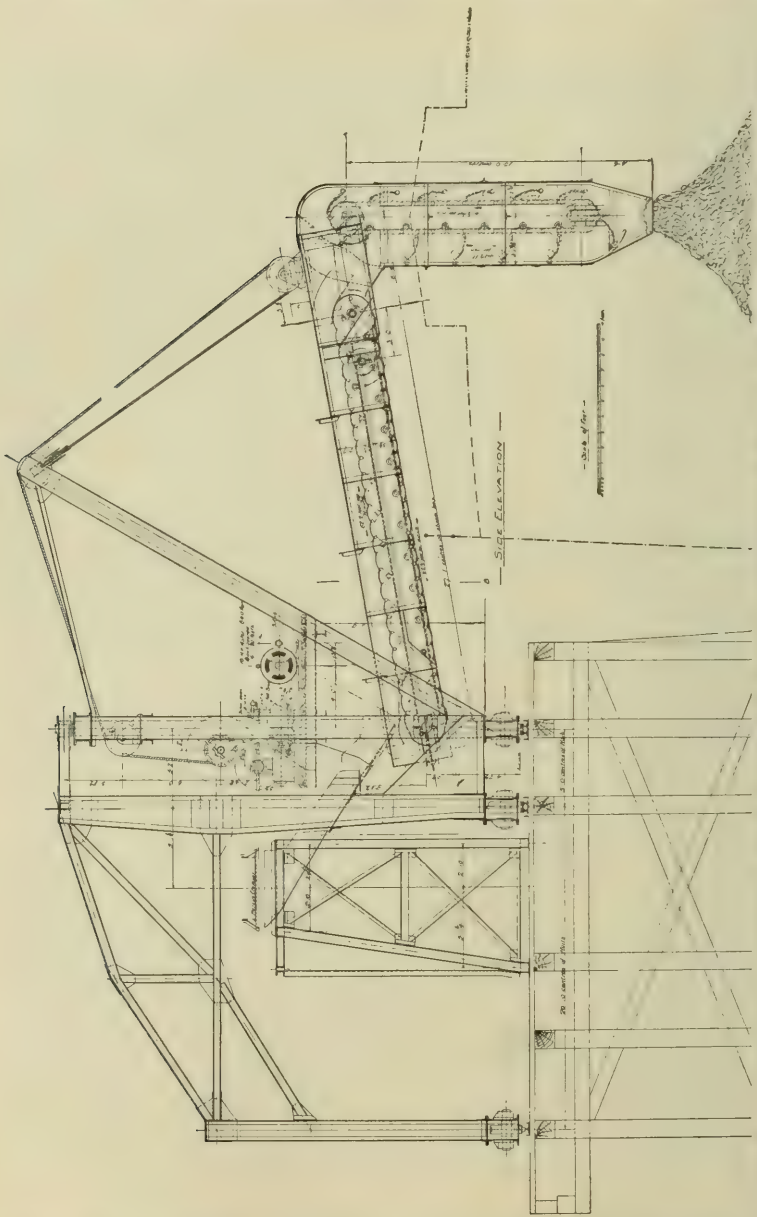


FIG. 61.—MOVABLE COAL-SHIPPER, WITH WRIGHTSON PATENT ANTI-BREAKAGE FILLER, ALEXANDRA DOCK, GRIMSBY (1907).

save hand-trimming. At the end of the jib is suspended a vertical belt, which moves in a trunk. This belt has large

trays working freely on hinges. These, in turning round the top drum and falling down on the inside, catch their outer edge against the inner plate of the trunk in an inclined position, each tray forming with the two side-plates and back-plate of the trunk a kind of coal-scuttle, of which the tray is the bottom, which moves downwards by the mechanical driving power from the drum. The tray, on arrival at the bottom of the trunk, discharges the coal as it passes the termination of the back-plate. The jib-belt rises and falls with the vertical belt, which follows the top of the coal, so that there is a continual stream of coal passing from one belt to another and down the vertical belt. The action of this third belt, although naturally helped by the force of gravity, is entirely controlled by the machinery. Figs. 1, 2, and 3 (Plate II., Vol. XV.) illustrates the arrangement.

It is claimed that by a suitable arrangement of railway-sidings and hoppers, several machines can be arranged so that all the holds in a vessel can be supplied at the same time. In this case, the machines are made to move parallel to the quay, and to the lines of railway, so as to plumb any position of hatchway.

(2) *Alexandra Dock, Grimsby.*—A recent application of the Wrightson coal-shippers and anti-breakage fillers, combined with a re-arrangement of the staithe head, was opened at the Alexandra dock, Grimsby, in August, 1907, when two of these shippers were arranged to take the place of the ordinary shoots. A general arrangement of this is shown in Fig. 60.

Instead of the movement of the trucks being left to the control of a small locomotive, the deck of the staithe was remodelled, and the wagons are now run by gravity until they come over two hoppers placed beneath the deck of the staithe; here bottom hopper-wagons are emptied direct into the hoppers, and end-tipping wagons are tipped by means of electrically-driven tippers. The coal is then conveyed, by means of flexible plate belts, to raised gantries, upon which are Marcus propulsion conveyors, from which the coal can be taken at openings to suit the positions of the hatchways of the vessel, or, if preferred, belts may be used instead of the Marcus conveyor.

The two shippers shown in Fig. 61 are moved on rails running the full length of the staithe, and can be set to suit any two hatchways. These shippers being provided with flexible plate

belts, carried upon the movable jibs, convey the coal from the spouts of the propulsion conveyors to the Wrightson anti-breakage fillers. The fillers are suspended at the end of the movable jibs, and can therefore be lifted over the hatchways and placed at any level in the hold of the vessel, without the aid of a crane or other appliance, thus ensuring speedy working. The apparatus can be adjusted to suit any height of tide, and it can also be raised to any height as the coal gets built up in the hold. Either of these movements can be made without stopping the loading operations.

The anti-breakage apparatus consists of a vertical downtake or trunk, which is suspended from the end of the movable jib, This steel trunk has a drum arrangement at both ends. The drums carry an endless-chain belt with large steel trays, spaced at regular intervals and working freely on hinges; these, on turning round the top drum, form a series of large hoppers or scuttles, the sides of which are the sides of the vertical trunk, and the bottoms of which are the descending trays. As each hinged tray arrives at the bottom of the trunk, it falls open automatically, and discharges it contents on the cone of coal forming gradually in the hold. The tray is then carried round the bottom drum of the belt in a vertical position, and rises on the outer half of the trunk until it arrives again at the top drum, when it is automatically turned over; and, descending again in a slanting position, it receives the coal near the top of the trunk.

The speed of the top drum in the trunk is regulated and controlled by the speed of the jib-belt; the weight of the coal in the descending scuttles assists the driving of the jib and trunk belts, the two belts being geared together by means of an endless chain. The coal thus quietly descends into the hold of the vessel, helped by the force of gravity, but entirely controlled by machinery.

The anti-breakage filler can be removed to a recess on the staithe by a side motion of the jib, and can easily be disconnected when the anti-breakage arrangement is not required. This side movement of the jib is also useful for plumbing any position of hatchway, or for assisting the trimming of the coal in the vessel.

It has been found at Cramlington, and also at Grimsby, that the output of the Wrightson anti-breakage coal-fillers has only

been limited by the supply of coal to the hoppers and by the time taken for trimming in the hold of the vessel; so that with modern turret-type vessels, and a constant supply of large capacity wagons, the full output will be obtained from their use,

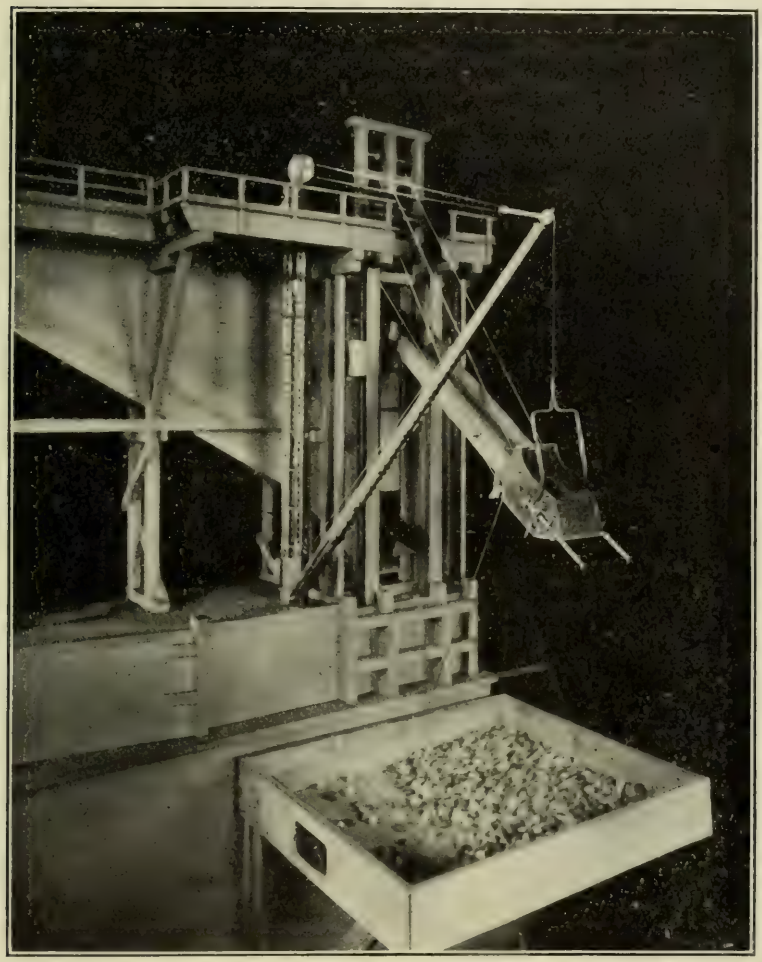


Fig. 62.—Anti-breakage Appliance: Early Box-drop Arrangement, Blyth.

which, with slightly increased speed and width of belt, can be easily made to deliver from 1,000 to 1,200 tons per hour.

(*c*) *Box-drop Arrangement.*—Comparatively recent experiments at Blyth have also been made by the North-eastern

Railway Company with a somewhat similar bucket, but which when empty fitted on to the end of the spout like a glove, and when filling automatically dropped to its lowering position. It was fitted with a projecting prong arrangement near its bottom, and, on coming into contact with the coal in or the bottom of the hatchway, the doors opened automatically (Fig. 62); but, although such improvements obviated the breakage from the end of spouts into the bucket, and also prevented long drops from the bottom of the bucket into the hatchways, it was not considered satisfactory in other ways.

(*d*) *Telescope Appliance.*—Experiments have also been made at Blyth, with the "telescope" similar to that in use at the Seaton Burn staithe on the Tyne (already described under high-level system, page 162), but it was felt that it did not fully meet the requirements.

(*e*) *Handcock Appliance.*—Recent experiments have been made with the Handcock arrangement, which, during tests extending over periods of 30 minutes' duration each, has proved capable of dealing with an average of 350 tons per hour without either any stoppages or breakdowns: that is, a quantity equal to about 60 per cent. of the maximum tonnage which can be handled at the ordinary shoots of the most modern laid-out arrangements, and, owing to present general conditions, about as much as can be handled at many places where only the ordinary facilities exist. It is assumed that 400 tons per hour will ultimately be reached, an extremely satisfactory advance on old records, combining as it will both careful handling and quick despatch.

Briefly it consists of a vertical iron downtake (Fig. 19, Plate XXXI.), weighing 3½ tons, which is suspended from the end of the teeming-spout, down into the vessel's hold, by means of a crane or other appliance: This iron downtake has an open side nearest the quay, which allows the end of the teeming-spout to be adjusted to any point according to the height of the tide, and also to be raised as the coal gets built up in the hold, either alteration being made without impeding the loading operations. A drum-and-sheave arrangement fixed at the upper end of the downtake, and a series of trays spaced at intervals inside the telescope, and worked by means of an endless chain, form a self-acting endless-conveyor arrangement. Impetus and constant

motion are given to the machine by the coal falling from the spout on to each succeeding tray in rotation, which, after tipping its contents at the bottom, makes its ascent in a hanging position on the outside of the downtake; and, as each in succession is carried over the top shaft of the arrangement, it falls back into position, and descends inside the telescope, receiving its load as it falls past the end of the teeming-spout. The inside of the downtake measures 4 by $2\frac{1}{2}$ feet, and the size of the trays is 4 by 3 feet, owing to an angle-iron guide at each side of the front of the downtake. As the trays are thus slightly wider than the interior of the downtake, they descend in a slanting position, and each holds, when full, about 8 hundredweight of coal. It will, therefore, be seen that the apparatus can be inserted through any hatchway above 4 feet in width. The speed of the machine is regulated by a brake, connected to the shaft and gearing at the upper end of the downtake, round which the endless chain works. This brake is automatic in its action, and keeps the speed of the moving trays constant, irrespective of the load on the appliance. To prevent leakages from the trays and the spout-end, sliding plates are fixed over the open side of the downtake. The whole arrangement can be either speedily placed in position to load best coal, or else uncoupled and placed on one side at will, and loading operations commenced in the ordinary way; and, if the downtake is made of sufficient length and suspended from the jib of a crane placed on the staithe head (enabling teeming operations to be entirely conducted from the topmost spout independently of the height of the tide), the excessive drop and the subsequent breakage when teeming from the lower level are thus avoided. This arrangement, together with the adoption of the larger class of wagon, diminishing the height of the drop into the spouts, should, it is anticipated, in the loading of steam- and house-coal, materially increase the efficiency of the operation without any appreciable reduction in the rate of despatch.

(*f*) *Ballan & Morison Appliance.*— Another contrivance to prevent the breakage of coal during teeming from the wagon to the spout end was introduced by Messrs. Ballan & Morison in 1900, but the idea has never been adopted, presumably owing to the fact that when the hopper and spout are kept fairly full of coal (thus allowing coal to be teemed out of the wagon on to the coal instead of clashing against the sides of the spout)

little breakage occurs until after it leaves the spout end, on its descent into the vessel's hold.* The idea of the inventor is to avoid the sliding of the coal down the staithe by substituting a trunkway about 3 feet square, fitted with openings at the waterside, from which the coal will run into the spout and thence drop into the vessel's hatchway, by means of arrangements intended to do automatically what is now done by the teemers by their hand-gear when they are shipping soft coal. This trunkway is hoppered to receive the coal from the truck, and, at the bottom of the hopper, there is a flap which opens as the weight of coal falls upon it, and closes when that weight is removed. This flap is connected with a door at the end of the spout. Inside the trunkway, there is a movable table, which is lowered by brake-power as the coal falls upon the table from the flap. The table is fitted with counterbalance-weights, so that when, owing to the rise of the tide, it is necessary to raise the level from which the coal is run into the spout, the brake may be liberated and the table allowed to rise, in the empty trunkway, to its original position under the flap of the bottom of the hoppers. The object is to maintain a column of coal measuring, say, 3 by 3 feet and 40 feet high, or whatever height may be necessary. In shipping at a lower level than the first one, the brake is used to lower the table, with the column of coal upon it, to the next opening in the front of the trunkway.

(*g*) *Rigg Systems.*—Mr. James Rigg, of London, is the inventor of three different types of anti-breakage drop appliances for the shipment of coal, in addition to a floating elevator.

(1) *Doors Released from Deck by Cord.*—Fig. 63 illustrates this system. Hydraulic or other power is here dispensed with, and the force of gravity alone utilized. Across the lower end of the shoot, but at a sufficient height to admit of the free passage of the coal, are fixed two brackets carrying a shaft, at either end of which rollers are keyed, and also a brake wheel which is controlled by a rope from the deck. Two wire ropes passing around these rollers are attached to the sides of a rectangular bucket, and at their other ends these ropes, passing over pulleys fixed

* The previously described and more recent invention of Mr. Handcock seems, however, to have got over this difficulty.

above the staithe framing, are connected to counterbalance-weights, which preponderate over the empty bucket; the reverse being the case when the bucket is loaded. The counterbalance-weights may be led, by means of guide pulleys, to any convenient out-of-the-way position on the staging. It will thus be seen that the man on deck operating the brake can easily determine the

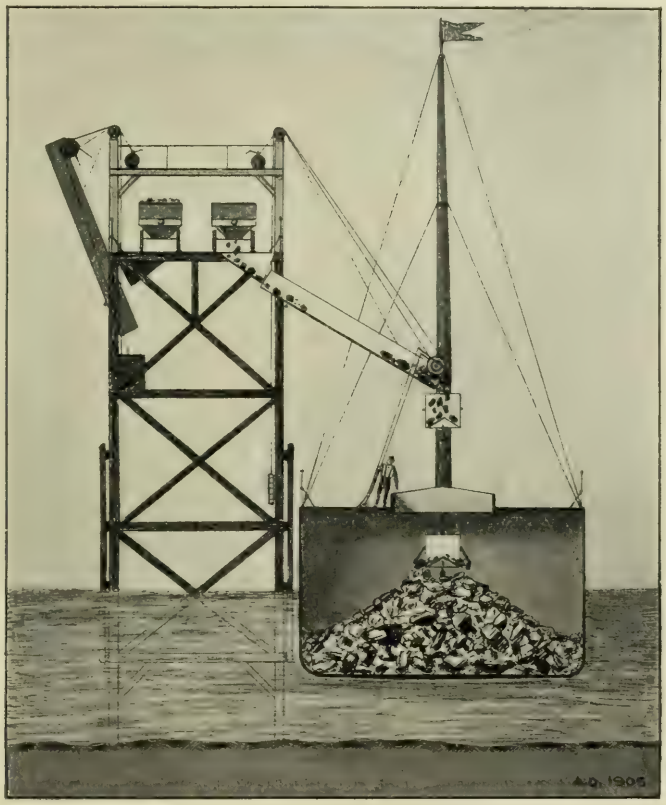


FIG. 63.—RIGG ANTI-BREAKAGE APPLIANCES: DOORS RELEASED FROM DECK BY CORD.

depth in the hold to which the bucket shall descend, and he can similarly control the pace at which the counterbalance-weights shall cause the empty bucket to return to the end of the shoot.

(2) *Door Released by Contact.*—Fig. 64 illustrates the bucket in use under this patent. The bucket is also suspended from the end of the shoot by two ropes and counterbalanced, as in Fig. 63,

its special feature being that it is automatically discharged by the curved links coming into contact with the floor of the hold or with the first piece of coal touched, and, releasing the doors, it discharges and delivers the coal not only without fall but, by spreading it, reduces the cost of trimming. On the brake being released, the counterbalance causes the instant return of the empty bucket to the mouth of the shoot. On the cone being formed, direct tipping operations will proceed. For narrow hatches the buckets are provided with single inclined floors.

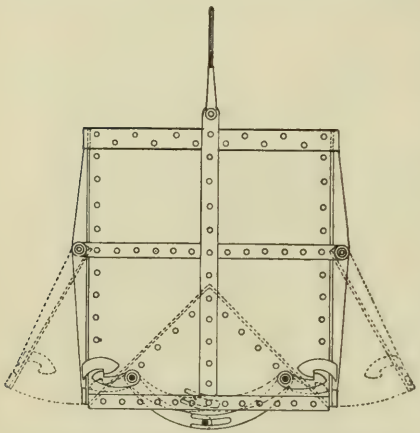


FIG. 64.—RIGG ANTI-BREAKAGE APPLIANCES: DOORS RELEASED BY CONTACT.

(3) *Continuous Chain of Buckets.*—The necessity for the automatic drop arises from the deterioration to which some descriptions of cargo, and coal more especially, are subject in their passage from the mouth of a shoot into the holds of steamers or other vessels. By means of the ship's tackle, the light steel frame is first placed on planks over the hatchway, and the chain of buckets on their frame is then dropped into position ready for work.

Fig. 65 illustrates the automatic drop lowering coal into the hold. The arrangement consists of the long beam or stay carrying an endless chain of buckets, the coal or other such matter passing

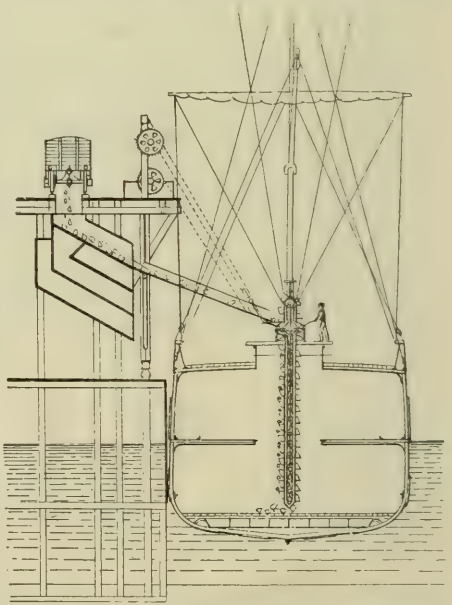


FIG. 65.—RIGG ANTI-BREAKAGE APPLIANCE CONTINUOUS CHAIN OF BUCKETS.

through a small hopper into those descending. The drum at the top is connected by means of bevil-gearing and a vertical shaft to the horizontal brake shaft, and thus controls the pace at which gravity would otherwise cause the coal or other cargo to descend. On the opposite side of the steel frame carrying the chain of buckets is a winch, for use in raising the drop when the ship's tackle is not available for this purpose. For lightness and facility in handling, it is constructed almost entirely of steel.

(*h*) *South Wales.*—Some form of hoist seems to be almost universally adopted in South Wales, together with an anti-breakage box, of which several different forms are in use: these may be classed as follows:—

(1) *Ordinary Anti-breakage Boxes.*—Figs. 20 and 21 (Plate XXXI.) represent the box most commonly used; it is constructed of iron, the upper half being of a triangular section and the lower half of rectangular shape. One side forms a door, which swings about a hinge at its top, and can be fixed when in its closed position by a bolt or trigger. When the full box has been lowered to the bottom of the hold, the pulling of a rope draws back the trigger and allows the box to empty, after which the door has again to be bolted by hand prior to its being lifted to the shoot-mouth for filling.

(2) *Thomas-Batchelor Box.*—Figs. 22 and 23 (Plate XXXI.) represent the Thomas-Batchelor box, which is suspended by a shackle at its extreme top. To the eye near the bottom, and on the right-hand side of the section, is attached a chain, the other end of which is fixed to the coaming of the hatch. The length of this chain is so regulated that, when the box is lowered to a predetermined point, this chain, by taking the weight, will cause the box to open and discharge its contents. As the cone of coal rises, the tipping chain has to be shortened. The box is made in two sizes, namely, of 1 ton and 2 tons capacity.

(3) *Other Forms of Box.*—Figs. 24 and 25 (Plate XXXI.) represent another form of box. In it, the crane is shackled to two hinged doors forming the bottom, the box being kept upright by guides near its top and enclosing its lifting chains. From the top of the body of the box chains lead to the hatch coamings, to which they are attached. The action, as will be

seen, is very similar to that of the Thomas-Batchelor box; but, inasmuch as the doors are in the bottom, it cannot discharge its load so quietly.

Figs. 26 and 27 (Plate XXXI.) represent another form of box, known as the George-Taylor anti-breakage box. In this case, a special appliance has to be added to the crane, so that a tipping-chain similar to that in a double-chain grab can be operated. The box consists essentially of two plate-ends, and two latticed sides. Hinged near the top of one of its sides is a jointed plate extending from end to end of the box. This plate is made in four leaves, two forming the back, one the front, and one the bottom of the box. The action as as follows:—The tipping-chain is hauled taut, and the shallow box thus formed is brought into position below the shoot; as it is loaded, the tipping-chain is lowered, thus increasing the depth and consequently the capacity of the box. On the box being lowered to the bottom of the vessel's hold, the tipping chain is slackened out, and the contents of the box are discharged quietly. The patentee, Mr. Taylor, died some years ago, and the appliance is not now in use, probably owing to a charge of 1d. per ton being made for all coal shipped by it, in addition to the usual charges.

Both the boxes shown in Figs. 22 and 23 and 26 and 27 (Plate XXXI.) are highly ingenious, but an outsider cannot but reflect that the breakage caused by the drop of 2 feet, when it concerns only on an average perhaps 60 tons of cargo, is almost negligible. There are two or three more forms of boxes, but they have a great sameness of action.

With the above anti-breakage boxes, to attain the maximum efficiency during shipment, the speed of loading should not exceed 100 tons per hour. It is claimed that 150 tons per hour has been loaded; but, as the boxes only hold about $1\frac{1}{2}$ tons, this equals 100 double trips per hour or nearly 2 per minute, at which rate it seems impossible to take full advantage of the anti-breakage part of the boxes, that is, of the coal being tipped a few feet below the shoot.

These various forms of anti-breakage box are all disliked by the workmen, and consequently are often dispensed with; and, when used, only about the first 50 tons of each cargo is handled in this way, after which the ordinary spout-teeming is adopted.

(4) *Lewis-Hunter System.*—Another form of anti-breakage arrangement is the Lewis-Hunter system (Fig. 66), in operation

Fig. 66.—Lewis-Hunter Patent Coaling Cranes, Bute Docks, Cardiff.

at the Bute and Queen Alexandra docks, Cardiff. The principle of the system is that the wagon is tipped into a large box, which in its turn is discharged into the vessel's hold. Figs.

28 and 29 (Plate XXXI.) illustrate this appliance, which consists of a rectangular box with a movable bottom, made of cast-iron, and pyramidal in shape. To the centre of it, the main crane chain is attached, and is carried through a guide in the hood of the box, so that when the box is being lifted by the chain it will still keep right-side up. Attached, one on each side of the guide of the main lifting chain, are two chains, also attached to the crane. When the box is being emptied, the weight is hanging from these two chains.

The action of the box is as follows:—It is first lowered empty into a pit of a depth equal to about three-quarters of the height of the box, so that the mouth of the box faces a tipping platform at one end of the pit. The wagon is brought on to this tipping platform, and its contents are tipped by a hydraulic tilting apparatus into the box (Fig.67). The hood of the box serves to prevent any of the coal from shooting into the bottom of the pit. On the wagon being tipped, it is taken from the platform, shunted among the empty wagons and a full one brought on to the platform. While this is being done, the full box is being lifted by the crane (the lifting chain being of course the one attached to the centre of the bottom) swung over the ship, and lowered into the hold. When the box is almost touching the bottom of the hold, the weight is taken by the two chains attached to the top of the hood; the pyramidal bottom is in consequence lowered out, and the coal sliding down the inclined sides is deposited very gently into the hold of the ship (Fig. 68). When the box is empty, it is again hoisted up by the chain attached to the pyramidal bottom, swung round, lowered into the pit, and again filled from the wagon already brought on to the tipping cradle.

There are, of course, two drops (if the discharge of the box into the hold can be called a drop), the second drop being small, varying from, say, 10 feet when the box is empty to practically nothing when it is full. The boxes are made in two sizes: one for the ordinary 10-ton wagon and one for handling a smaller one, generally of 7 tons; but this smaller one is gradually being replaced by the 10-ton size, or even larger still. There is no doubt that this system is equally applicable to the large 30-ton wagon, and can be laid down at no prohibitive cost, as 7 or 10 tons of the larger wagon-load could as easily be tipped into the existing boxes as the whole of a smaller wagon; and thus the only

modification needed would be in connexion with the tipping cradles.* The Cardiff Railway Company have the exclusive

Fig. 67.—Lewis-Hunter Patent Coaling Cranes, Bute Docks, Cardiff: The Coal being transferred from the Wagon to the Box.

use in the Bristol Channel of these cranes, which have proved

* The author is informed that since writing this description the new Lewis-Hunter cranes erected at the Queen Alexandra dock can ship 20-ton wagons.

by far the most satisfactory appliances for shipping Welsh coal with despatch and the least possible breakage. Colliery-

FIG. 68.—BOX OF LEWIS-HUNTER PATENT COALING CRANE: SPREADING THE COAL.

screened coal shipped by the cranes, it is claimed, is equal to double-screened coal shipped by ordinary staithes, besides

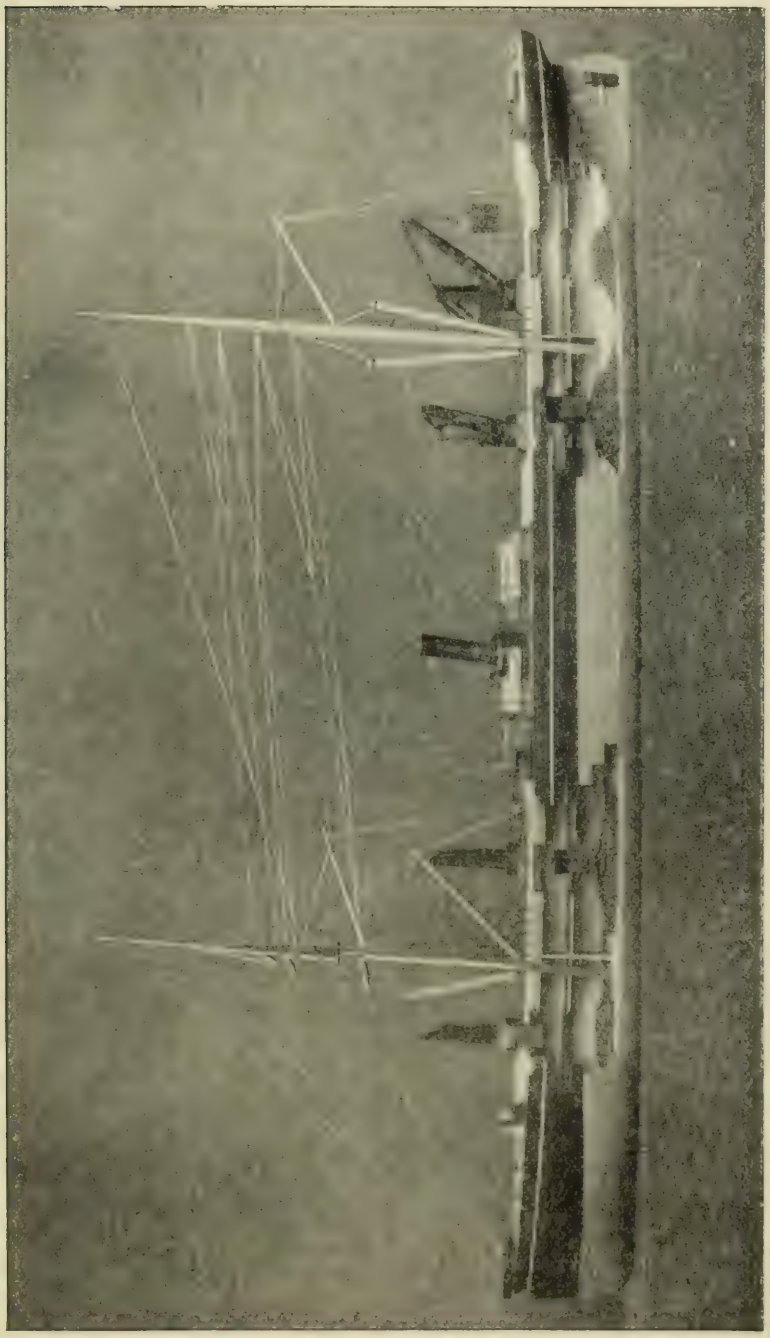


FIG. 69.—PARTIAL SECTION OF STEAMER ILLUSTRATING THE LEWIS-HUNTER METHOD OF LOADING.

ensuring great saving in breakages and uniformity of distribution throughout the cargo of any small coal which might exist. Thus also is minimized any risk of spontaneous ignition from small coal in cargoes bound for distant ports. Similar to those operating at the Bute docks, three or more cranes can be worked simultaneously into one vessel (Fig. 69), and as much as 330 tons have been shipped by one crane in an hour, and 6,715 tons have been shipped into a vessel in 11 hours, or an average of 610 tons per hour. Many trunk and turret steamers load full cargoes of coal by such cranes without any manual aid whatever. Shippers also attach so much importance to them that they frequently elect to wait for a crane berth rather than have their coal shipped from the usual staithe.

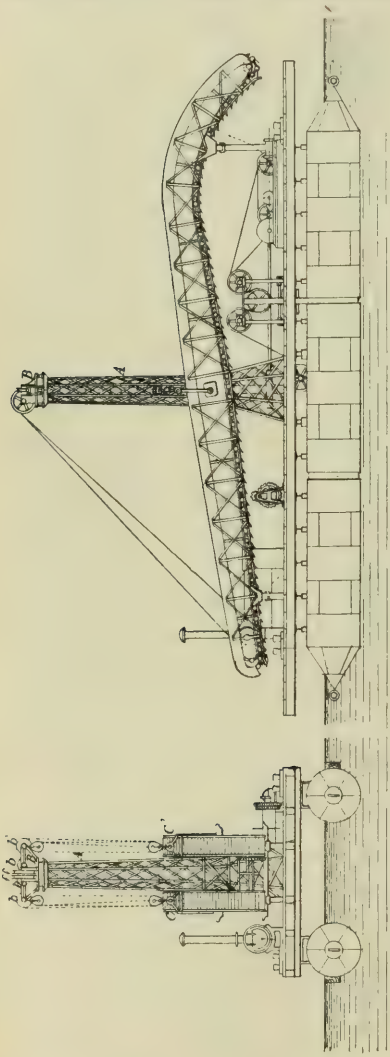


FIG. 71.—FRONT VIEW OF RIGG FLOATING ELEVATOR.

FIG. 70.—SIDE VIEW OF RIGG FLOATING ELEVATOR.

V.—FLOATING ELEVATORS.

Rigg Floating Elevator for Bunkering Coal and Loading Grain. — This invention of Mr. James Rigg, in 1882, was intended to supersede the present method of bunkering coal, etc., from barges or lighters into the holds of steamers, or on to a quay side, such work being usually performed by workmen passing baskets up the ship's side. The machinery is carried upon pon-

toons, three on each side, each 20 feet long by 6 feet in diameter, the deck being about 74 feet long by 24 feet beam. The central lattice tower, *A* (Figs. 70 and 71), carries a revolving head, *B*, to which is suspended a pair of steel lattice girders, CC^1, curved at their lower ends, carrying two endless chains of buckets travelling upon flanged rollers, these being driven by a steel-wire rope from the pair of winding-engines, as shown. These engines are also used for raising and lowering the girders as well as turning them through a quadrant, in order that they may be stowed away fore and aft, as shown in Figs. 70 and 71. Clutches are arranged to throw any of the three sets of gearing in or out as required for the purposes mentioned, and hand-crabs enable the ends of the elevator girders to be adjusted at pleasure to suit the coal or grain in the barge, and the height of the steamer or quay. In cases where it is desired, the elevator is readily so arranged as to be self-propelling.

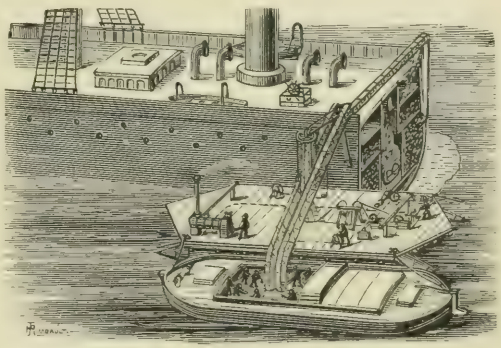


Fig. 72.—Rigg Floating Elevator: Bunkering a Steamer.

The endless steel-wire rope referred to is about 350 feet in length, and in Fig. 72 is seen bunkering coal to a steamer shown in section. The buckets are wider and flatter than those employed for loading grain, and the pair of 7-inch bore winding-engines employed on the Lower Danube for this purpose delivered it at a rate exceeding 150 tons per hour.

For the transhipment of coal, the pace of loading is only limited by that at which the six or eight men finding accommodation at the foot of the elevator can fill up the passing buckets or trays. As coal must necessarily under these circumstances be raised by manual labour and placed in the elevator trays, the rate per hour of transfer cannot rightly be compared with that of its descent from gravity from any system of tipping machine or automatic drop.

VI.—Conclusion.

In conclusion, the writer must express his indebtedness to Sir Thomas Wrightson, Bart. (Messrs. Head, Wrightson, & Company, Limited), Sir William Thomas Lewis, Bart., Messrs. C. A. Lambert, R. Urwin, R. E. Ornsby, J. R. Gilchrist, R. S. Anderson, G. H. Sheffield, J. D. Twinberrow, C. S. Carnes, J. Rigg, J. T. Tannett Walker, H. Roe (of Ropeways, Limited), Hydraulic Engineering Company, Chester, Joseph Fairless, C. & A. Musker, H. Lander, Anthony George Lyster, Norman R. Redmayne (Sir W. G. Armstrong, Whitworth, & Company, Limited), and others, for their kindness in allowing him to inspect their various arrangements and in giving him the information asked for.

VII.—Appendices.

I.—Trimming Rates at Tyne Dock.

The following is a summary of trimming rates in operation at Tyne Dock, near South Shields. Those, however, for gas-coal average about 3d. per keel higher at the Tyne Commission's spout on the northern side of the river. A keel is equal to 8 Newcastle chaldrons of 53 hundredweights each, or 21½ tons.

Clause.	(1) *Steamers.*	Gas-coal. Per Keel. s.	d.	Steam-coal. s.	d.	Coke. s	d.
1.	Single-decked steamers not exceeding 16 feet from coaming to bulkhead	2	9	3	0	5	0
1A.	Single-decked steamers with a hold 16 feet and under at one end of the hold, and exceeding 16 feet at the other, the rate for that hold to be	2	11	3	4	5	4
2.	Single-decked steamers exceeding 16 feet from coaming to bulkhead	3	0	3	6	5	6
3.	Two-decked steamers	5	0	5	6	6	6
4.	Three-decked steamers (bunkers included), if three decks	6	6	7	6	8	0
5.	Steamers taking coals or coke in lower hold only: to pay same rate as if loading up.						
6.	Steamers partly one deck, two decks, and three decks: to pay as per construction under clauses Nos. 1, 2, 3, and 4.						
7.	Steamers loading coke and exceeding 16 feet throw: to pay, over and above the foregoing rates, 6d. per keel (except under clause 2).						
8.	Steamers taking in bunkers when loading cargo at spouts: first 90 tons, at cargo rate; above 90 tons, if put into side-bunkers, 9d. per chaldron; if put into thwart bunkers, cargo price according to construction, provided that coal is teemed down a hatchway of not less than 12 square feet where a spout can be used; if not, 9d. per chaldron.						
9.	Steamers taking bunkers only: side or thwart bunkers, one deck, 6s. per keel; two decks, 7s. 6d. per keel; three decks, 8s. 6d. per keel. Coals put into holds proper, through cargo-hatch, to pay cargo-rate.						

10. Coals in between-decks only of any hold, 7s. 6d. per keel; coals on deck, 3s. per keel.
11. Oil steamers: side bunkers, 10s. per keel; thwart bunkers, 7s. 6d. per keel; trunk bunkers, 14s. per keel.
12. Levelling coals, extra 1s. per keel over and above the tariff rate; levelling coke, extra 1s. 6d. per keel over and above the tariff rate. This rule to apply to each hold separately.
13. Vessels having one-fourth of the quantity on board in any hold, to pay 1s. per keel over and above the tariff rate, for the quantity shipped in said hold.
14. Shifting and stowing coals at the end of holds, 8s. per keel; coke, 11s. per keel; trimming coke in side bunkers and difficult places other than holds proper, 11s. per keel.
15. Screened house- and cannel-coal, to pay steam-coal rate.
16. Ballast, other than coals, in holds or on deck, 4d. per ton.
17. Putting coals in at end of bridge, provided they can be put in with the plates, 10s. per keel.
18. Vessels exceptionally difficult or easy to trim: a special arrangement to be made, of which notice must be given to the staithemaster prior to commencing loading, otherwise the usual tariff must apply.
19. All disputes to be referred to the staitheman, one trimmer, and the shipowner or his representative. Failing to agree, the shipowner and trimmer mutually to appoint an umpire, whose decision shall be final.

(2) *Sailing Ships.*

	Gas-coals. Per Keel. s.	d.	Coke. s.	d.
Not exceeding 20 keels, with end-hatchways, single-decked ...	3	6	5	6
Do. do. do. double-decked ...	5	0	7	0
Do. do. do. single-decked ...	4	0	6	0
Do. do. do. double-decked ...	5	6	7	6
Above 20 keels, and not exceeding 25 keels, with end-hatchways, single-decked ...	4	0	5	6
Do. do. do. with end-hatchways, double-decked ...	5	0	7	0
Do. do. do. without end-hatchways, single-decked ...	4	6	6	0
Do. do. do. without end-hatchways, double-decked ..	5	6	7	6
Above 25 keels, down 1 hatchway, single-decked	4	0	6	6
Do. 2 do. do.	4	6	6	0
Do. 3 do. do.	4	0	5	6
Do. 1 do. half double-decked	5	6	7	3
Do. 2 do. do.	5	0	6	9
Do. 3 do. do.	4	6	6	3
Do. 1 do. double-decked	6	0	8	0
Do. 2 do. do.	5	6	7	6
Do. 3 do. do.	5	0	7	0
Do. 1 do. treble-decked	7	0	9	0
Do. 2 do. do.	6	6	8	6
Do. 3 do. do.	6	0	8	0

Levelling tir, as per clauses Nos. 12, 13, and 14 for steamers, to apply. Steam-coal rate for sailing ships, same as for River Tyne, etc. Five per cent. to be added

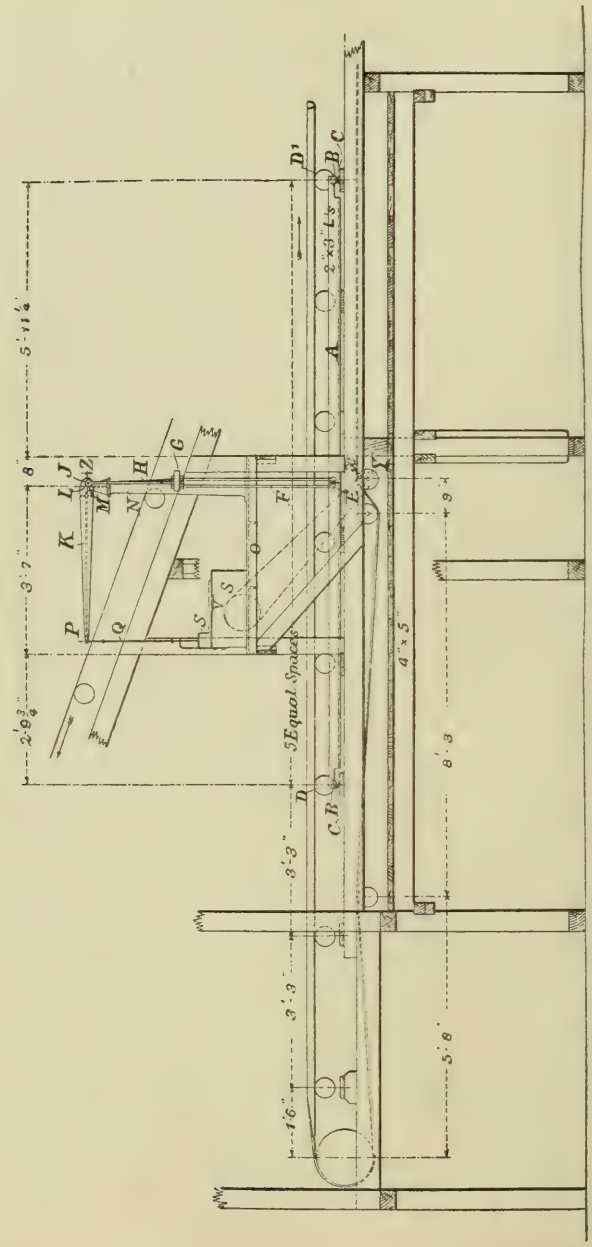


FIG. 73. — MERRICK CONVEYOR WEIGHTOMETER ATTACHED TO BELT-CONVEYOR SYSTEM.

to coke rates in steamers and sailing-vessels. Sailing-ships exceeding 16 feet, but not exceeding 24 feet throw, to pay, over and above the tariff rate, 6d. per keel ; if over 24 feet cast, a special arrangement to be made. Vessels taking in stiffening coals to pay 10s. extra per ship. All hatchings are to be made available at the foregoing rates. Captains are to settle for the trimming as soon as the loading is completed. All disputes to be referred to the staitheman, one trimmer, and the shipowner or his representative. Failing to agree, the shipowner and trimmer mutually to appoint an umpire, whose decision shall be final.

II.—Description of Merrick Conveyor Weightometer.

Figs. 73 and 74 show the mechanism applied to a 16-inch Robins belt-conveyor. It will be seen that four of the troughing idlers are bolted at each side to the underside of four equal lengths of angle-iron, the adjacent ends are separated sufficiently so that they can move independently of one another, and the outer ends are provided with knife-edges resting in bearings.

Long suspension-rods, *F*, carry the inner ends of the angles to a cross-head, *G*, which is suspended from the knife-edges, *J*, on the outside of the end of the steelyard, *K*, by means of the two short rods, *H*.

The four idlers and belt with its load between the troughing idlers are thus freely suspended from the steelyard, so that one-half of the weight of the belt, together with a proportionate part of the weight of the idlers and material on the belt, is transmitted to the steelyard.

The forked steelyard, *K*, is made of aluminium, in order to reduce its weight and thereby its inertia, and moves on knife-edges in bearings on the bracket, *M*. From the long end, *P*, of the steelyard is hung a frame of steel tubing, *Q*, to the lower ends of which is attached a hollow cast-iron cylinder floating in a mercury bath to steady the motions of the weigher.

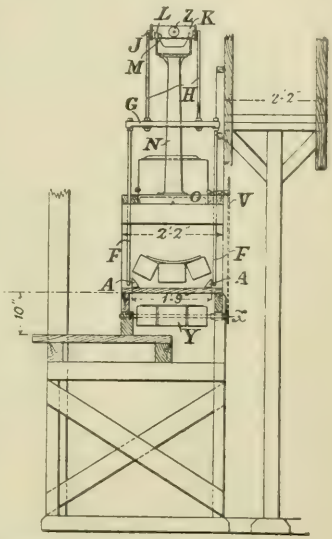


Fig. 74.—End View of Merrick Conveyor Weightometer attached to Belt-conveyor System.

To these rods are also attached a gaff supporting the integrating wheel in such a way that this wheel will be tilted around an axis going through its centre to correspond with the motions of the weigher. If the conveyor is empty, the integrating wheel will remain stationary ; and, if material is carried over the conveyor, the integrating wheel will be tilted a corresponding amount.

Around the periphery of the integrating wheel are mounted a series of integrating rollers, each turning freely upon its own axis, but prevented from sliding axially thereon.

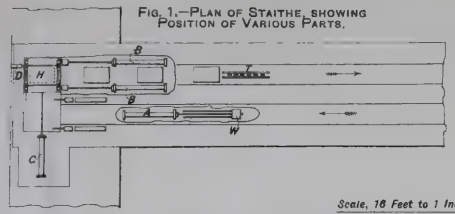
An endless leather belt is so located that it touches two of the integrating rollers at diametrically opposite points. This belt is driven through sprocket wheels and chain from the return conveyor-belt, so that it will also run at a speed in the same proportion as the conveyor speed.

If the integrating wheel is stationary, and there is no load on the belt, the endless belt will simply revolve two of the integrating rollers on their own axis, but, if the integrating wheel is tilted, there will be a resultant causing the integrating wheel to rotate around its own axis, and the more it is tilted the quicker it will revolve. This motion is in exact proportion to the amount of material carried on the belt. Through suitable gearing, the motion of the integrating wheel is transmitted to an ordinary numerical counter, which can be graduated to suit each separate case.

Owing to its extremely simple theory of operation and absence of all complex motions and multiplicity of frictional parts, the accuracy of the results obtained can be guaranteed to meet any usual and reasonable requirements so far as the weighing of material in bulk is concerned.

WALL COAL-HANDLING APPARATUS.

Fig. 1.—Plan of Staithe, showing Position of Various Parts.



Scale, 16 Feet to 1 Inch.

Fig. 3.—Section of Loading End of Staithe.

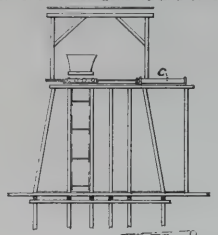
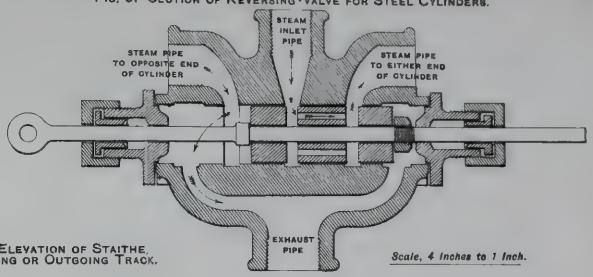
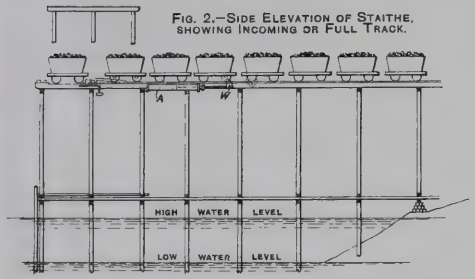


Fig. 5.—Section of Reversing-valve for Steel Cylinders.



Scale, 4 Inches to 1 Inch.

Fig. 2.—Side Elevation of Staithe, showing Incoming or Full Track.



Scale, 16 Feet to 1 Inch.

Fig. 4.—Side Elevation of Staithe, showing Teeming or Outgoing Track.

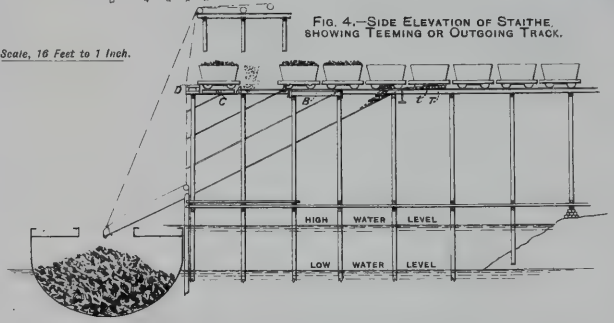
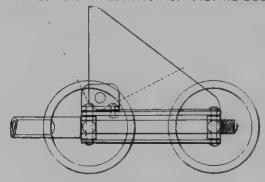
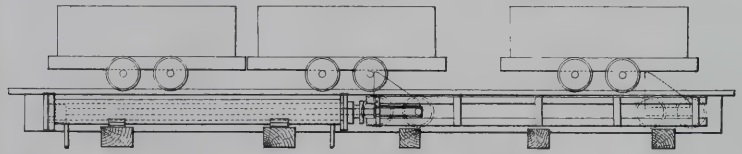


Fig. 9.—Side Elevation of Tilting-dog.



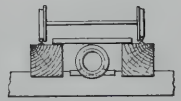
Scale, 4 Feet to 3 Inches.

Fig. 6.—Section showing Connection of Cylinder, Piston-rod, and Tilting-dog Arrangement.



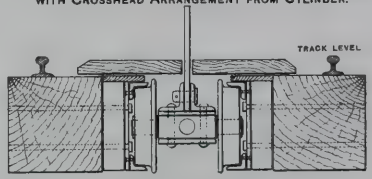
Scale, 4 Feet to 1 Inch.

Fig. 7.—Cross-section showing Position of Cylinder below Track Level.



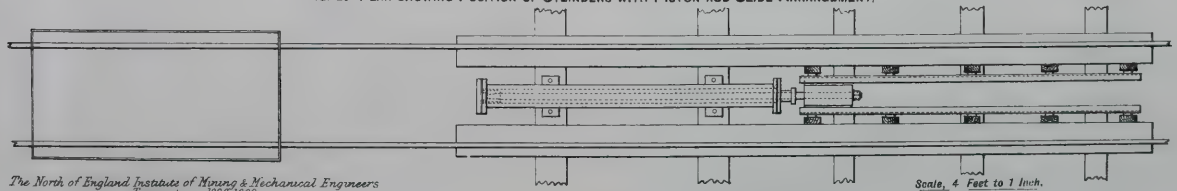
Scale, 4 Feet to 1 Inch.

Fig. 10.—Section showing connection of Tilting-dog, with Crosshead Arrangement from Cylinder.



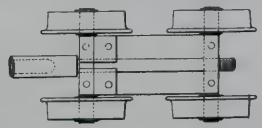
Scale, 4 Feet to 3 Inches.

Fig. 8.—Plan showing Position of Cylinders with Piston-rod Slide Arrangement.



Scale, 4 Feet to 1 Inch.

Fig. 11.—Plan of Working Crosshead.



Scale, 4 Feet to 3 Inches

And.w Reid & Compy.y Ltd. Newcastle upon Tyne.

The Institution of Mining Engineers
Transactions 1908 1909

To illustrate Mr. John Kirsopp Jun's Paper on "Coal-shipment and the Laying-out of Staithe Heads, etc."

Vol XXXVI, Plate XXX

SEATON DELAVAL COLLIERY STAITHE AT NORTHUMBERLAND OR HOWDON DOCK.

FIG. 12.—PLAN OF STAITHE

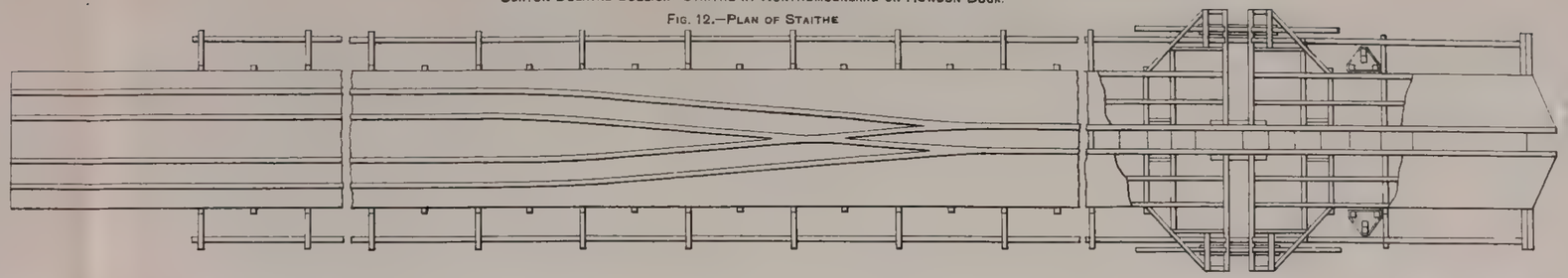


FIG. 14.—END ELEVATION OF STAITHE.

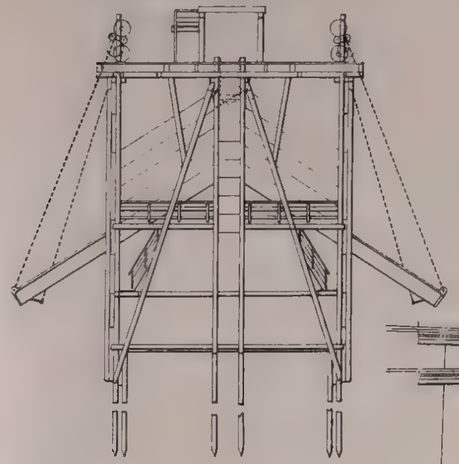
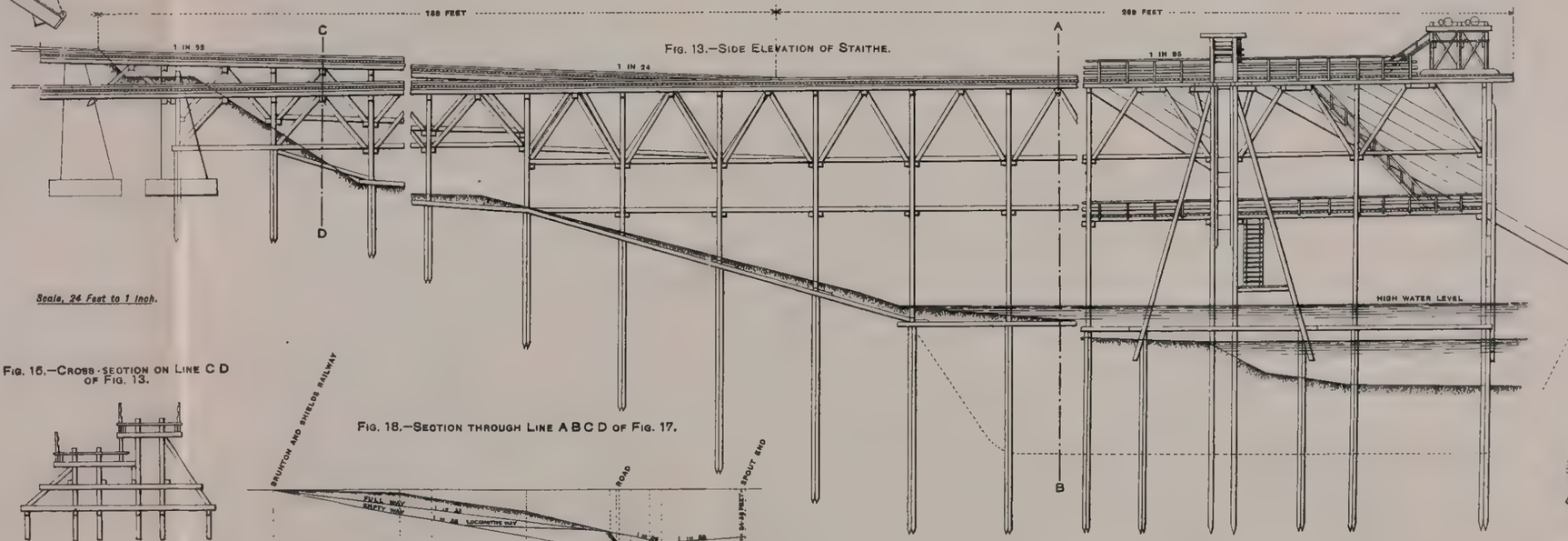


FIG. 13.—SIDE ELEVATION OF STAITHE.



Scale, 24 Feet to 1 Inch.

FIG. 15.—CROSS-SECTION ON LINE A B OF FIG. 13.

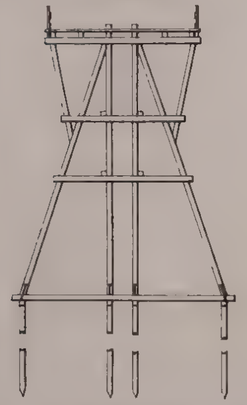


FIG. 16.—CROSS-SECTION ON LINE C D OF FIG. 13.

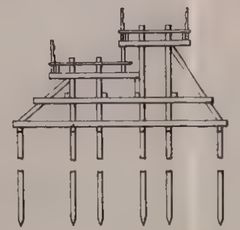
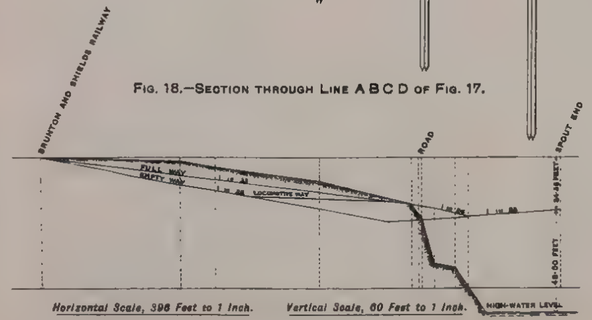


FIG. 18.—SECTION THROUGH LINE A B C D OF FIG. 17.



Horizontal Scale, 396 Feet to 1 Inch. Vertical Scale, 60 Feet to 1 Inch.

FIG. 17.—PLAN OF RAILWAY TO STAITHE AT NORTHUMBERLAND OR HOWDON DOCK

Scale, 198 Feet to 1 Inch.

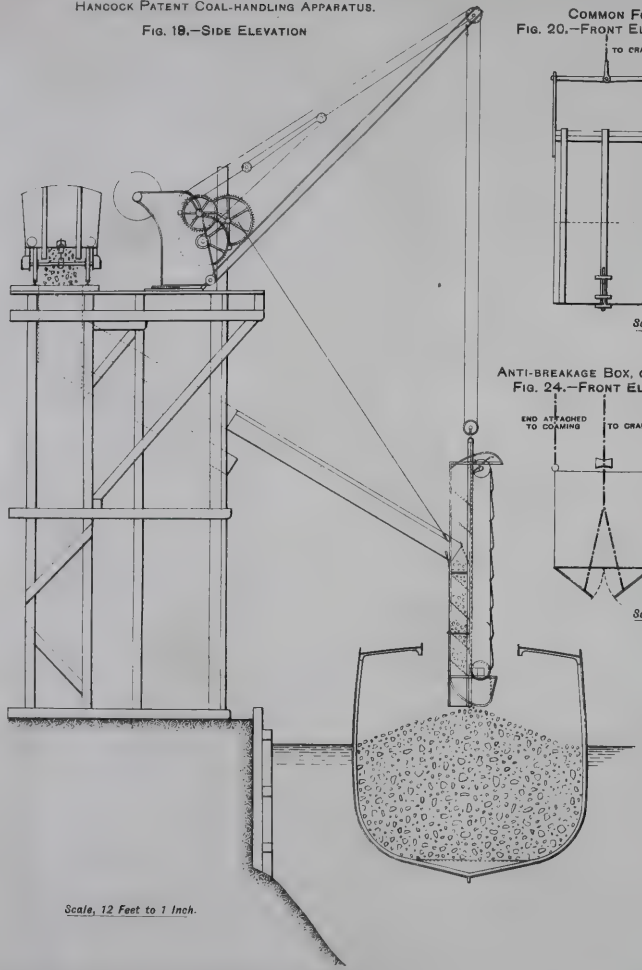
The North of England Institute of Mining & Mechanical Engineers
Transactions 1908 1909

And.r Reid & Comp.y L.td Newcastle upon Tyne

Vol LIX. Plate VII.

Hancock Patent Coal-handling Apparatus.

Fig. 19.—Side Elevation

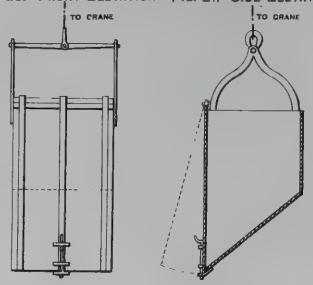


Scale, 12 Feet to 1 Inch.

Various Types of Anti-breakage Boxes.

Common Form of Anti-breakage Box.

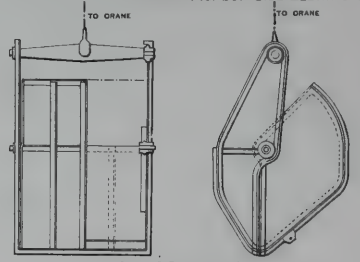
Fig. 20.—Front Elevation Fig. 21.—Side Elevation.



Scale, 4 Feet to 1 Inch.

Thomas-Batchelor Anti-breakage Box.

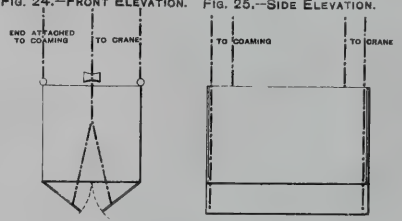
Fig. 22.—Front Elevation. Fig. 23.—Side Elevation.



Scale, 6 Feet to 1 Inch.

Anti-breakage Box, on the Thomas-Batchelor Principle

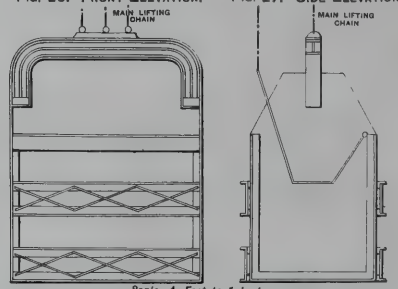
Fig. 24.—Front Elevation. Fig. 25.—Side Elevation.



Scale, 4 Feet to 1 Inch.

George-Taylor Patent Anti-breakage Box.

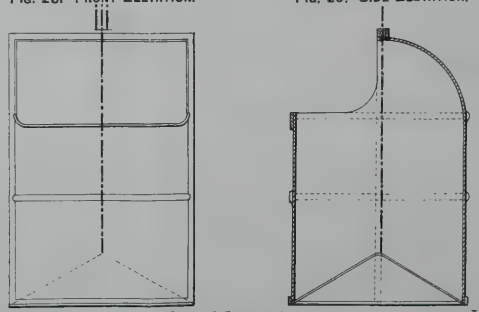
Fig. 26.—Front Elevation. Fig. 27.—Side Elevation.



Scale, 4 Feet to 1 Inch.

Lewis-Hunter Patent Anti-breakage Box.

Fig. 28.—Front Elevation. Fig. 29.—Side Elevation.



Scale, 16 Feet to 3 Inches.

The North of England Institute of Mining & Mechanical Engineers Transactions 1908 1909.

Andⁿ Reid & Compʸ Lᵗᵈ Newcastle upon Tyne

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
JUNE 12TH, 1909.

MR. J. B. SIMPSON, PAST-PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on May 22nd and that day.

The SECRETARY read the balloting list for the election of officers for the year 1909-1910.

The following gentlemen were elected, having been previously nominated: —

MEMBERS—

Mr. HAROLD PERCY BELL, Mining Engineer, Pendlebury Colliery, Bentley, near Walsall.

Mr. THOMAS BLANDFORD, Mining Engineer, Main Street, Haltwhistle, S.O., Northumberland.

Mr. DAVID MACDONALD CHAMBERS, Mining Engineer, 23, St. Mary's Mansions, Paddington, London, W.

Mr. HENRY WILLIAM CLOTHIER, Engineer, 3, Park Villas, The Green, Wallsend, S.O., Northumberland.

Mr. ROBERT GRUNSON, Colliery Underground Manager, Minas Errazuriz, Lebu, Chile, South America.

Mr. GEORGE CHRISTOPHER LLOYD, Secretary, Iron and Steel Institute, 28, Victoria Street, London, S.W.

Mr. ARTHUR TRISTMAN MARKS, Mining Engineer, c/o The Nile Valley Gold-mining Company, Limited, 15, Copthall Avenue, London, E.C.

ASSOCIATES—

Mr. PERCY BARKES, Overman, Houghton Colliery, Fence Houses.

Mr. CHARLES WERNER PATTINSON, Overman, Milburn House, Darlington Road, Ferry Hill.

Mr. JOHN EDWARD YOUNG, Master Shifter, 1, Westcott Terrace, Deanbank, Ferry Hill.

STUDENT—

Mr. ARTHUR LEWIS SCOTT OWEN, Apprentice Mining Engineer, 6, Success Terrace, Fence Houses.

The following paper, entitled "A Short Description of the Various Types of Coal Cargo-steamers and of Doxford's New Self-discharging Steamer," by Mr. John Kirsopp, Jun., was taken as read: —

A SHORT DESCRIPTION OF THE VARIOUS TYPES OF COAL CARGO-STEAMERS AND OF DOXFORD'S NEW SELF-DISCHARGING STEAMER.

By JOHN KIRSOPP, Jun., F.G.S.

Introduction.—The writer is of opinion that this short communication will form a useful addendum to his paper on "Coal-shipment and the Laying-out of Staithe Heads,"* especially as several improvements in the build of coal-carrying boats have of recent years taken place, and these improvements are still continuing. Among one of the most important of these may be mentioned a new type of self-discharging boat in course of construction by Messrs. William Doxford & Sons, Limited, of Sunderland, which may have a tendency to revolutionize the coal-transit trade of the near future. Mechanical contrivances, and the laying-out of the general surface arrangements for the handling of the loaded and empty wagons at the place of shipment, now render it possible for teeming operations to be performed so that the speed of coal-shipment in most parts of the world at the present time is entirely governed by the build and type of vessel, that is, by the amount of coal that can be teemed into the vessel before the necessity arises for starting trimming operations, and afterwards the rate at which such trimming operations can be performed. Another very important development, the principle of which will be either proved or condemned within the next few months, lies in the "monitor" type of construction, which is claimed to possess several advantages over the existing forms.

It may be of interest to recall that the "John Bowes," built at Palmer's shipbuilding yard in 1857, was the first iron steam collier built on the Tyne. This vessel was of the single-deck type, and until a year or two ago was regularly running from the Tyne in the coasting trade, when the writer believes that she was sold abroad (being re-named the "Transit"), and is still sailing under the Swedish flag.

* *Trans. Inst. M. E.*, 1908, vol. xxxvi., page 610.

The following is a list of the usual types of vessels suitable for carrying coal:—

(1) (*a*) Single-deck (old and new types), (*b*) raised quarter-deck, (*c*) two or three decks; (2) trunk type; (3) cantilever-framed type; (4) turret type; (5) monitor type; (6) vessels arranged to unload by grab-gear; and (7) vessels arranged to unload by belt-mechanism.

Types 2, 3, 4, and 5 are equally applicable as types 6 and 7 to be fitted up with either grab-gearing or with belt-mechanism. Types 2 to 7 are what are commonly known as "self-trimmers."

FIG. 1.—TRUNK TYPE OF VESSEL.

(1) *Single-deck Type.*—(*a*) The old single-deck was the first type of boat to be built. The difference between the old and the improved type of single-deck boat is that the bulwarks are lower and the hatches only 2 or 2½ feet higher than the main deck, as compared with at least 3 feet higher than the main deck in the old type of boat. The new type also has less hold obstruction inside the vessel, which facilitates the handling of the cargo, and consequently slightly lessens the amount of trimming required to be done at the time of loading operations. The absence of iron decks below the top (or weather) deck in the

larger types of boat permits of greater deadweight being carried; the absence of a steel deck usually involving an increase of framing, which reduces the tonnage while not materially reducing the space, and thus makes a clear hold for the manipulation of bulk cargoes.

(*b*) The raised quarter-deck type differs from the single-deck type only in having a raised quarter-deck. This type of vessel was constructed partly owing to the loss of cargo space occupied by the shafting and enclosed by the tunnel, it being found that with a preponderant volume of space forward the tendency was for the vessel to trim by the head; therefore part of the after length of the ship was increased in depth to give a more uniform distribution of the weight of cargo, and also trim, to the vessel.

(*c*) The three-deck type of boat is the heaviest form of construction. In this type the main deck is the uppermost deck, and this and the middle deck are generally of steel or iron, and caulked. The lower deck consists of beams spaced wide apart, extending only in the holds. This type of boat was designed for general cargo purposes with the intention of keeping two, three, or more shipper's cargoes separate; but it is generally a very bad one to trim with coal cargoes, as the coal fills up in a heap below the hatch-coamings, and trimmers are required to descend to trim the coal under the deck and into the corners of the holds. A boat 400 feet long will carry, roughly, 7,000 tons, inclusive of bunkers. It is estimated that a space of 43 to 45 cubic feet (52 cubic feet for light Scotch coal) is required for a ton of coal. In a double-deck boat of 7,000 tons deadweight there would be a loss of 5 per cent. in her carrying capacity, as compared with a single-deck boat of the same size, owing to the space lost in trimming coals put immediately under the middle deck. Only from 300 to 500 tons (and even less, depending upon the size of the vessel) can be teemed into this type of vessel before trimmers are required to descend into the holds.

(2) *Trunk Type.*—This type (Figs. 1 and 2), the invention of Mr. Robert Ropner, of Messrs. Ropner & Sons, Limited, Stockton-on-Tees, is an ordinary single-deck steamer, with a square trunk or top extending between the forecastle and bridge

and between the bridge and poop. In this type the height of the trunk is the height of the poop and forecastle, and forms a continuous erection between these points, the top of the trunk forming a deck at a height of about 7 feet above the main deck. This trunk may be about 60 per cent. of the breadth of the vessel.

It is claimed for this type of vessel that it has all the advantages of a "single-decker," when designed clear of all hold-beams, side-stringers, quarter-stanchions, etc.; and also that the centre-line pillars are portable, and can be entirely removed whilst carrying timber and other bulky cargoes. These centre-

Fig. 2.—Section of Trunk Type of Vessel.

line pillars, however, are of very great service for securing the shifting boards when grain, coal, or like cargoes are carried. A boat of this type has been built 255 feet long, with only one clear hold, which extended the entire length of that part of the vessel devoted to the cargo, the engines being aft. The hold was not divided in any way, and there was practically only one hatchway, running the complete length of the hold. There was only one break in this continuous hatch, caused by the erection of a flying bridge, placed about its centre, for navigation purposes.

(3) *Cantilever-framed Type.*—This type of vessel (Figs. 3 and 4) is constructed on lines comprising advanced improvements of inventions by Messsr. Sanderson and Livingston of Jarrow, Mr. J. Priestman of Sunderland, and Messrs. G. M. Harroway and W. & T. Dixon of Middlesbrough. It has top-side water-ballast tanks, formed by the weather-deck, the ship's side, and an oblique

FIG. 3.—CANTILEVER-FRAMED TYPE: SECTION OF SINGLE-DECK VESSEL.

inner shell, so that they are practically triangular in section, and extend along each side of the vessel until the curvature of the vessel's ends renders it impracticable to continue them further, the inner edge being extended up to and forming part of the hatch-coaming.

The oblique sides and freedom from hold obstruction in this type reduce the amount of trimming required, making it the best self-trimmer, in addition to being the strongest boat, with the most water-ballast. It is also claimed to be one of the biggest deck-load carriers, and has one of the largest and clearest holds with the largest form of hatchways, together with the lowest

register, and the greatest possible safety. The hold capacity is as much as 52 cubic feet per ton deadweight, the deadweight being nearly three times the net register. This vessel has also a low net register tonnage, and consequently the cargo ratio of deadweight cargo is low, which is an advantage for deck-load carrying capacity. The general construction is of a strong form, due to the top tank inner plating forming box-girders, in

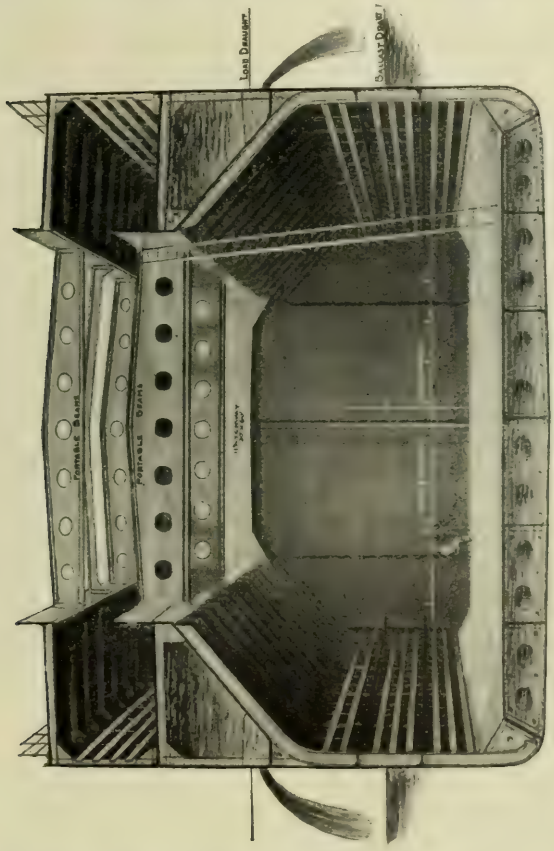


FIG. 4.—CANTILEVER-FRAMED TYPE: SECTION OF SHELTER-DECK FORM OF VESSEL.

order to resist longitudinal and lateral strains, but the surplus buoyancy is the same as in the ordinary form of vessel.

As constructed by the firm of Sir Raylton Dixon & Company, Limited, of Middlesbrough, the boat is built either as a single-deck type (Fig. 3), or as a shelter-deck type for passengers, cattle, etc. (Fig. 4). The sloping sides of the topmost tanks render the holds perfectly self-trimming, and there is little or

no necessity for any trimmer to go on the boat at all during coal-loading operations, as the hold is absolutely self-trimmed up to the top of the hatchways, and only requires a little levelling before the hatches are put on, although, of course, there may be a small amount of trimming necessary in the coal-bunkers. The hatchways are of enormous size, as much as 30 feet wide and 60 feet long; and, as the side of the hatchway is only about 8 feet from the ship's side, this wonderfully facilitates the loading by means of grabs, which is being regularly done at Montreal at the rate of 1,000 tons per hour.

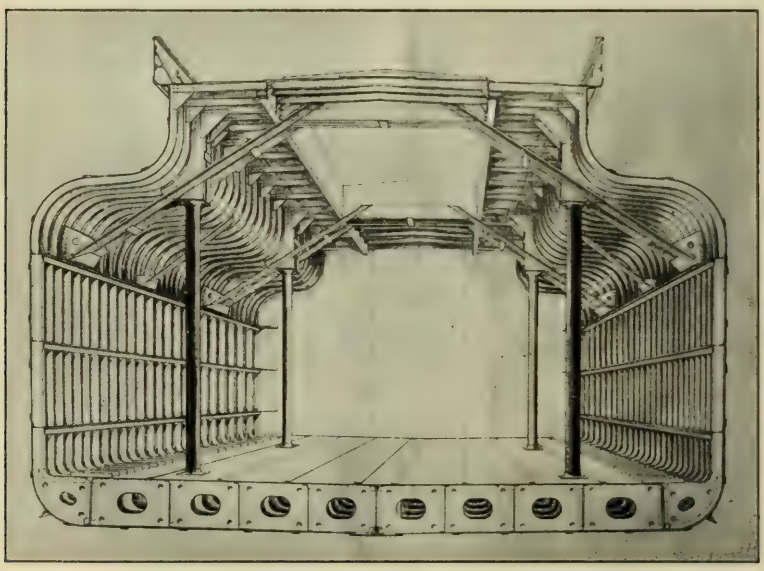


FIG. 5.—TURRET TYPE: SECTION OF VESSEL.

(4) *Turret Type.*—The turret build of steamer (Fig. 5) was designed as a self-trimmer, and is principally constructed by Messrs. William Doxford & Sons, Limited, of Sunderland. It is exactly the same above the load-line as the preceding types. The point of difference in the construction above the load-line is that there is a raised centre extending from stem to stern, the height of which is about one-fourth of the height of the depth moulded, and forms a superstructure, which creates a feeder to the holds, termed the "turret." The hatch-coamings are at least 2 feet above the superstructure or turret-deck. This

type of vessel, owing to the sides of the superstructure forming girders of great strength, allows for an economy in hull weight and permits of very long hatchways being made, which enables such boats to be practically "self-trimmers," the increased depth in relation to the length also assisting in producing a stronger vessel. The breadth of the turret of the earlier types (1892) was about 40 per cent. of the maximum breadth of the vessel, and experience proved that the amount of trimming to be done in such a boat was between 5 and 10 per cent. of the entire cargo, but certainly always less than 10 per cent. The builders, however, are now designing this type of boat with an increase in the width of the turret to 60 per cent. of the maximum width of the vessel, thus not only considerably increasing the general capacity, but at the same time still further reducing by 50 per cent. the small amount of trimming required when loading coal. It may be said that with the improvement in the breadth of the turret which constitutes a portion of the hold, the carrying capacity over the three preceding types of boat is increased by 12 per cent.; whilst the height of the raised turret above the main structure is one-quarter of the depth moulded, thus varying in direct ratio with the size of the vessel.

(5) *Monitor Type* (William Petersen's patent). This type of vessel is very similar to the turret type. It has two main features: firstly, like the turret type, it is a vessel the form of which comprises the greatest strength with the least expenditure of material, giving clear holds for cargo; and it has the advantage of being able to proportion the internal cubic contents to suit any particular volume which experience teaches is required for any cargo for which the ship is designed. Consequently, there are none of the unnecessary vacant spaces such as exist in other vessels and are measured into the tonnage of the vessel without being remunerative to the owner. This is attained by dispensing with sheer, joining all the erections together, and making them into a superstructure the width of which is about 60 per cent. of the vessel's breadth, at the half height, extended at the top and bottom to give about 4 feet extra width in order to afford better coal-teeming facilities, a wider superstructure deck, and more cubic feet of space. The second main feature is the application of two projections to the outside of the vessel

(below the load water-line on each side) in the form of rather flat arcs gradually curved into the flat sides of the vessel above and below and also between the arcs.

The projections have been found to reduce the amplitude of the waves, and the power saved in consequence permits of an economy in horsepower and in coal consumption. They also give greater displacement and deadweight of cargo, without increasing the tonnage.

Combining these two features in one ship makes the vessel about 5 per cent. less in size than the ordinary form of construction, and enables it to carry coal cargoes more economically, whilst possessing all the advantages of clear hold spaces for the easy handling of coal in and out. It is absolutely self-trimming, safer in stability, and steadier, because the retarding effect of the projections reduces rolling, and it produces the smallest vessel possible to carry the given deadweight of cargo.

These two main features need not be embodied in one vessel. If the monitor projections alone are applied, without the improved upper works, then the vessel need only be of ordinary form, with sheer and the usual erections, or may possess the special features of any other type. Therefore, the addition of the projections in such a vessel either gives an increase of speed with more deadweight cargo, or the same speed is retained with a reduction of coal consumption and horsepower, and consequently an increase of deadweight, so that the monitor projections occupy the unique position of being able to further improve any other existing type of vessel in point of speed, coal consumption, horsepower, and deadweight cargo and bunkers.

In the manipulation of coal cargoes this type can be arranged with hatches as large as any type now on the market; it can have equally long holds with equal freedom from obstructions; and it can be designed to be absolutely full without trimming, and to have all spaces occupied. Any required amount of water-ballast can be arranged to suit the draft, trim, and stability. It becomes, therefore, a suitable vessel on which any system of belt arrangement can be fitted up and carried for the discharging of cargo.

A vessel of this type (Fig. 6) is now under construction at the shipyard of Messrs. Osborne, Graham, & Company, of Hylton, near Sunderland. It is claimed for this type that the improve-

ments (namely, the increased capacity of the water gained by the semi-circular arcs along the sides of the vessel and other

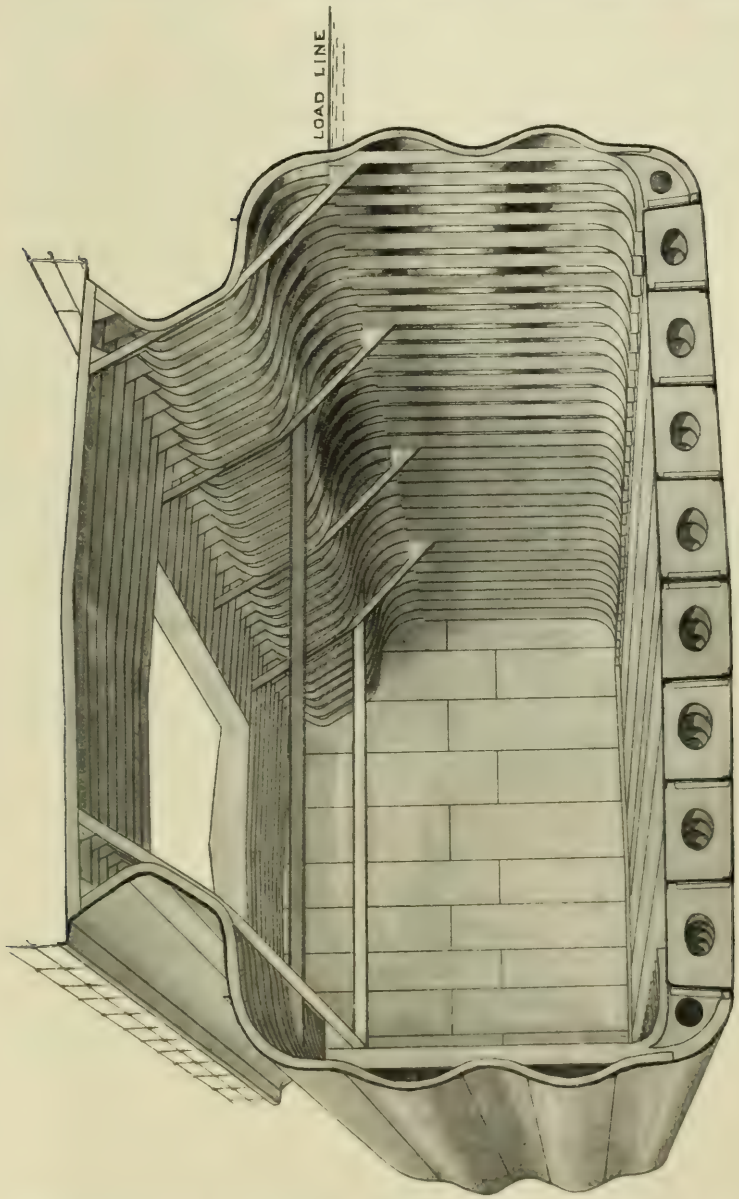


FIG. 6.—MONITOR TYPE: SECTION OF VESSEL.

features) give an increased carrying capacity over the first three preceding types of boats of 14 per cent.

(6) *Vessels arranged to unload by Grab-gear.*—Fig. 7 represents another type of boat as constructed by Messrs. William Doxford & Sons, Limited, of Sunderland. The vessel is arranged so that the coal gravitates towards the centre of the hatches, owing to the tank top being sloped up towards the vessel's sides.

Similarly to the other types of self-trimmers, these vessels are made with exceptionally large hatches, so as to facilitate the loading; and, as the capacity is arranged to suit all kinds of coal, they are capable of loading the whole of their deadweight, and are, in fact, capable of taking about one-third of their dead-

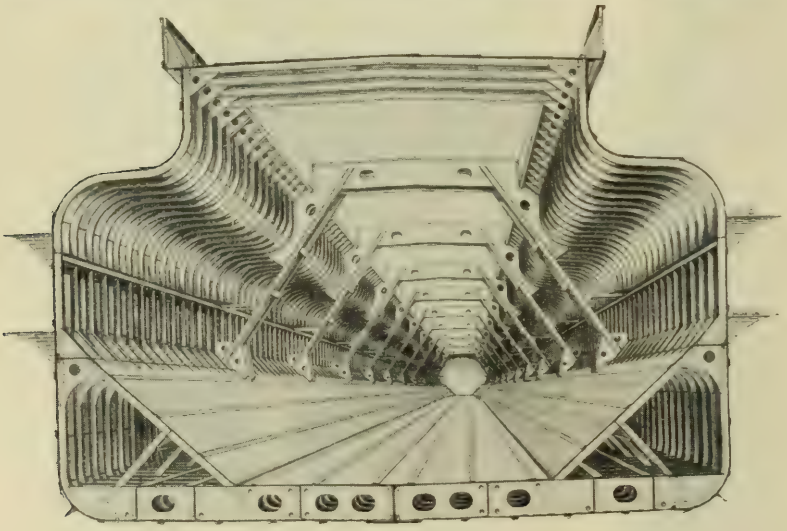


FIG. 7.—SELF-TRIMMER TYPE: SECTION OF VESSEL ARRANGED TO UNLOAD BY GRAB-GEAR.

weight in ballast, although whether it is advisable to put so much weight at the bottom of a vessel is questionable, as there is a possibility of thus making the vessel too stiff.

The coal is discharged by means of grabs, which can be fixed on the ordinary type of ship's derrick; and these grabs can be filled, raised, and discharged in one minute, equal to 90 tons per hour per grab.

It is only necessary to have one man to work each grab. He not only does the lifting, lowering, opening, etc., of the grab, but by an ingenious arrangement he can also slew the derrick overboard without any loss of time, and without moving

from the position necessary for manipulating the grab. This type of vessel is best adapted for the coal and ore trades, although it cannot be compared for cheapness of discharge with the continuous-belt type of discharge.

(7) *Vessels arranged to Unload by Belt Mechanism.*—Messrs. William Doxford & Sons, Limited, of Sunderland, are at the present time building a 3,000-ton deadweight steamer on this principle. If successful, it may revolutionize the class of coal- and ore-carrying vessel, and may be expected to become prominent in the near future; and as the now proved and coming method of speedy coal-loading will in all probability be the universal adoption of the endless-belt method, so will the lowering standard of freights, by the adoption and employment of steamers of this description, enable Great Britain to hold her own against the competition of the more inland situated coal-fields of the Continent and elsewhere. The vessel now under construction is of the single-deck self-trimming type, with large hatches and subdivisions in the hold, or a single continuous hold from machinery space to forepeak, the machinery and boilers being placed aft (Figs. 8, 9, 10, and 11). The cabin accommodation is fitted in the bridge, the crew space in the forecastle, and the navigation accommodation about amidships. The after hatchways are extended by trunks to the poop-deck level, being so arranged as to give the vessel a proper trim when loaded with full bunkers; and the usual high coamings are fitted on the poop-deck and on the main deck forward.

The bottom of the vessel is constructed on the cellular system for a suitable breadth, and the inner bottom is then raised and sloped upwards in the wings and built into the sides of the vessel, forming a suitable incline for gravitating the cargo on to the conveyors, and also giving the vessel the advantage of being about half loaded when in ballast and bunkers.

In the centre-line is constructed a slope-top tunnel extending throughout the hold from the engine space to the forepeak (Figs. 8, 9, 10, 11, and 12), and between this tunnel and the raised portions of the double bottom are placed the conveyor-belts, which are of the Robin patent construction type, one in each side of the vessel (Fig. 12). The sides of the tunnel below the level of the hatchways over the belts are open for free access to the belts and carriers at all times.

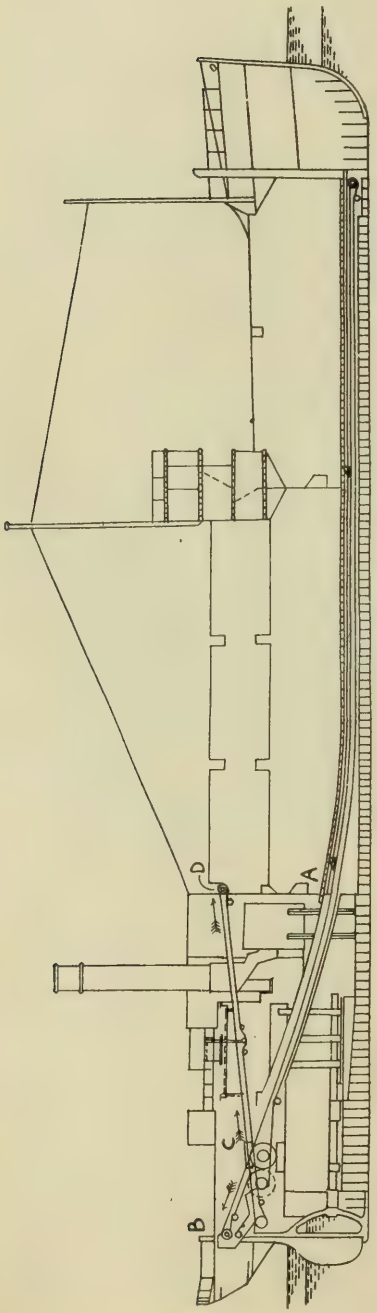


Fig. 8.—Self-discharging Vessel: Longitudinal Section showing the Arrangement of Belt-conveyors.

Over these conveyor-belts are constructed strong iron guide-plates running the full length of the hold, and partly covering the belts, leaving a 24-inch hatch over a 36-inch belt. This space is covered in the holds by cross-laid hatch-covers, say 11 inches in length by 3 inches in thickness, which support the cargo and leave the conveyors free to work without carrying the load.

At the after end of the hold a portion of the hatch, over which the 11-inch hatch-cover is omitted, is covered by a horizontal iron slide-door, *A* (Fig. 8), operated by a ratchet in the tunnel. On the foreside of the bulkhead is constructed an access chamber, in free communication with the tunnel, which is of such a form as to partly protect the slide-door from cargo when loading, and in the floor of this projection of the chamber is fitted a flap-hatch to give access to the hold from the tunnel.

At the after end of the cargo space, the conveyors rise from the horizontal and pass upwards in iron chambers through the machinery space, and then into the conveyor-driving engine-house, discharging the load in the

stern of the vessel into guide-shoots, *B* (Figs 8 and 9), which carry the load on to return belts, *C*, extended forward on both sides on the deck to any suitable point that may be required, but usually terminating at the fore-end of the machinery space, or poop-front, *D* (Figs. 8 and 9). The load is there delivered on to the terminal conveyors, *E* (Fig. 9), carried in swivel booms (which are raised or lowered and swung outboard) to the points of delivery (Figs. 10 and 11), and the cargo is in this way conveyed direct to the truck or barge without shoots. These booms also swing across to the reverse side of the vessel, so that both booms can deliver simultaneously into trucks or warehouse. Another important feature of this discharging arrangement lies in the method of delivering the cargo on to the belts from the hold, allowing the operator to have full control and free access at all times to the conveyors and to the face of the cargo. He can thus superintend and direct the continuous flow, and is able to at once prevent the cargo from bridging or choking the aperture leading to the belt, and thus ensure a continuous and uninterrupted delivery.

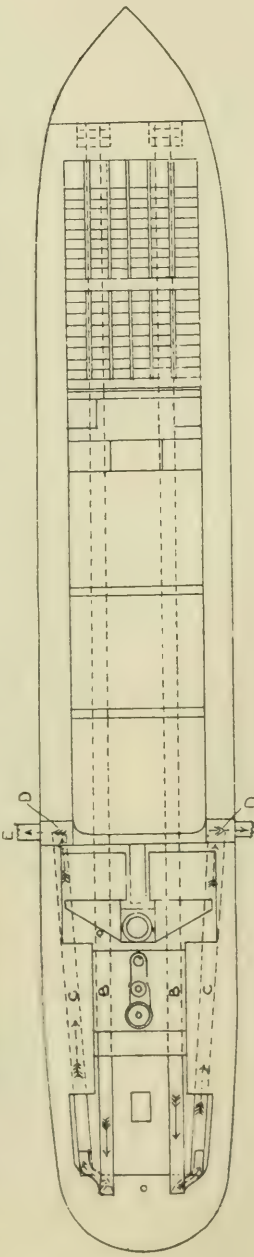


FIG. 9.—SELF-DISCHARGING VESSEL: PLAN SHOWING THE ARRANGEMENT OF BELT-CONVEYORS.

The operation of unloading a coal cargo is as follows:—Presumably the holds are full and the cargo lying solid, except under the overhang of the chamber on the bulkhead over the slide-door, at which point the space is naturally but partly filled. The slide-door in the covers over the conveyors is drawn back by the operation in the

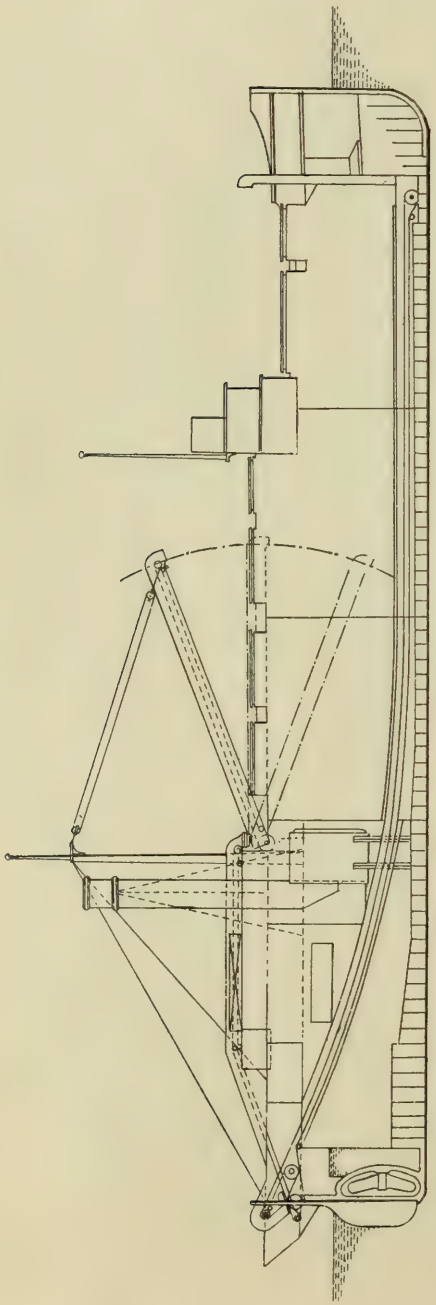


FIG. 10.—SELF-DISCHARGING VESSEL: LONGITUDINAL SECTION SHOWING THE POSITION AND ARRANGEMENT OF THE DISCHARGING BOOMS OR SHOOTS TO REACH TO THE DELIVERY TERMINALS.

tunnel, and the loose coal over it immediately runs on to the conveyors, which may or may not have been started. If running, then the flow continues; if standing, no harm is done, as the conveyor is only filled at that point, and the aperture becomes blocked and only clears itself when the belt is started, and then the flow begins. If no bridging occurs, the after part of the hold is rapidly emptied on to the conveyor which is carrying it on deck and into the receiving trucks or barges. If, however, any bridging is threatened, the operator in the tunnel ascends to the chamber and has free access over the aperture to correct any block. If bridging occurs higher in the hold, then he breaks it by means of a pinch-bar through prick-holes in the chamber sides.

When the after end of the cargo has run to its natural angle of repose, the operator,

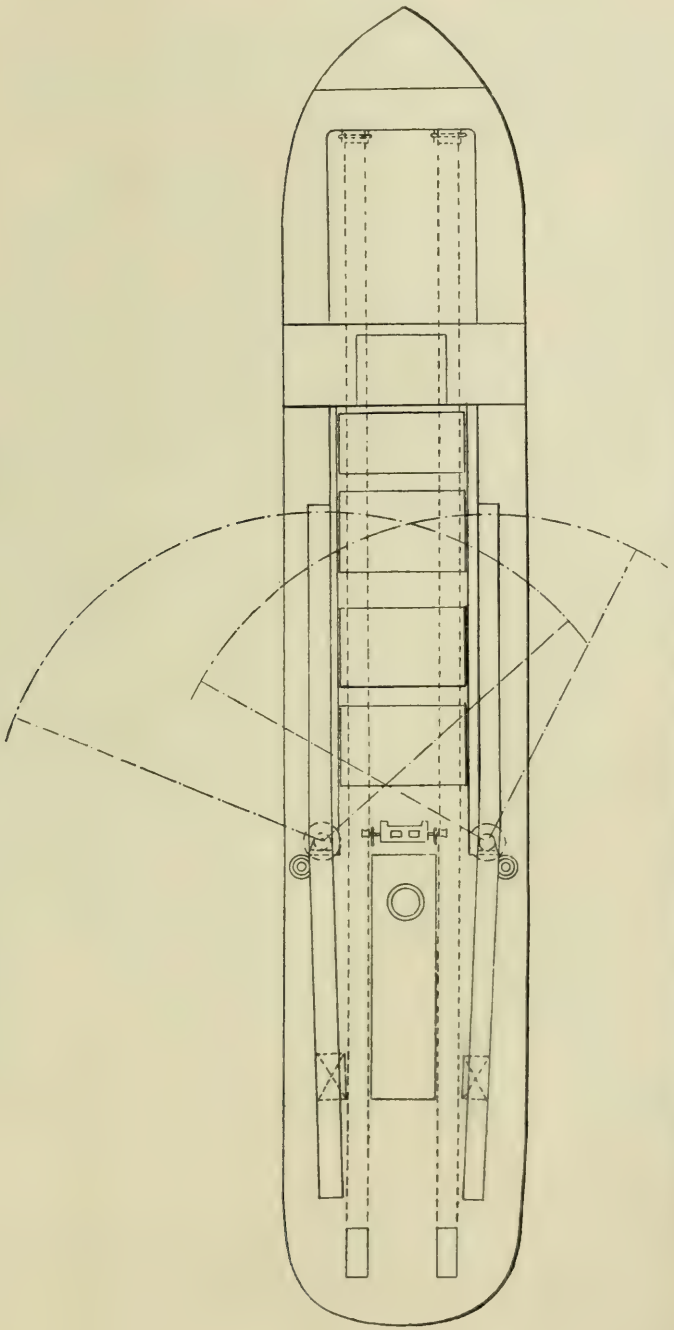


FIG. 11.—SELF-DISCHARGING VESSEL: PLAN SHOWING THE POSITION AND WORKING SWINGING RADIUS OF THE BOOMS OR SHOOTS TO REACH TO THE DELIVERY TERMINALS.

now in the hold, merely removes the first cover and places it aft of the aperture, and thus allows another portion of cargo to run, he being in a free position to maintain the run and correct any inclination to bridging and to big rushes. If such occurs, and

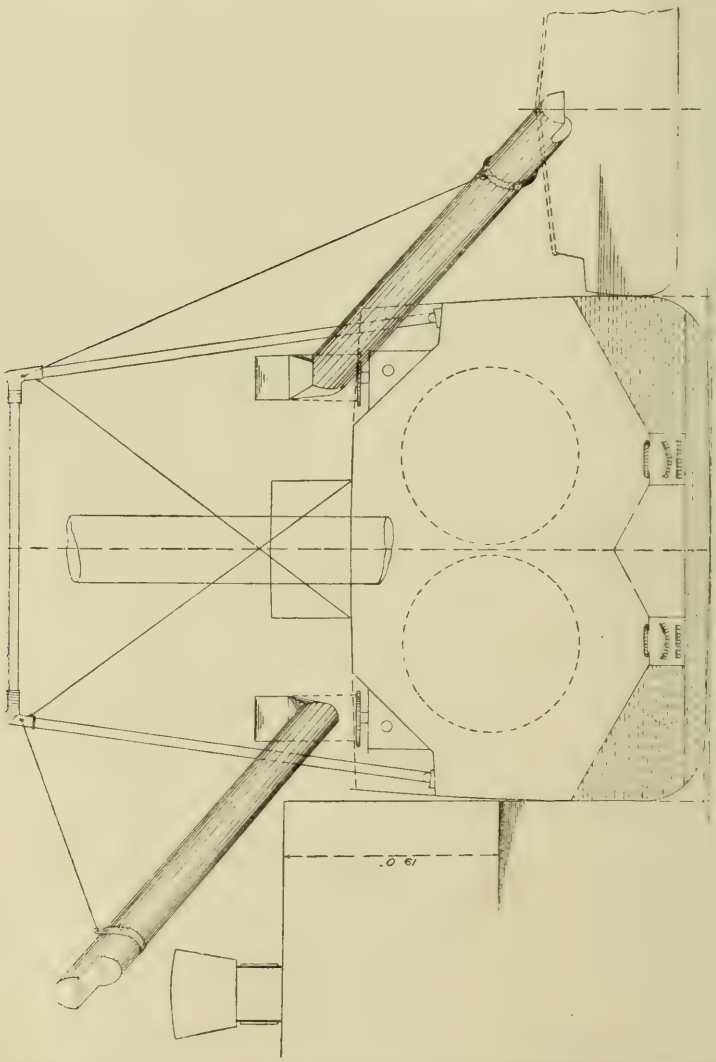


FIG. 12.—SELF-DISCHARGING VESSEL: SECTION SHOWING THE POSITION OF THE CENTRE TUNNEL AND BELT-CONVEYOR AT THE BOTTOM OF THE HOLDS, AND THE WORKING ARRANGEMENT OF THE BOOMS OR SHOOTS AT THE DELIVERY TERMINALS.

is likely to block the aperture, he again corrects this, and having run so much more he removes the next segment of cover, and so on, gradually transferring the aperture from the after end to the fore end of the hold.

The wing tanks and the central tunnel being sloped (Fig. 12), the cargo gravitates to the aperture, and the finals are manipulated by the operator, one man being on each side of the hold. Figs. 13, 14, and 15 indicate the belt-discharge arrangement, as fitted to coaling craft, suitable for delivering bunkers or cargo to large or small craft, the final discharge being on a belt carried in such a manner as to enable it to be raised or lowered, or swung round as shown, thus preventing any damage to the coal as in the case when the ordinary types of shoot are used.

An important feature is an inclined shoot, over which all the cargo passes on to the belt, which is carried on travellers on the guide-plate sides, and is moved forward from stop to stop to correspond with the movement of the aperture, thus allowing of two men to manipulate a whole cargo, at the rate of 500 tons per hour.

The conveyor driving-engines are of the compound surface-condensing type, worked from main boilers, and are under the direct control of the engineer of the vessel, who has at all times free access to all the gear for oiling, overhauling, or adjustments, when such are necessary.

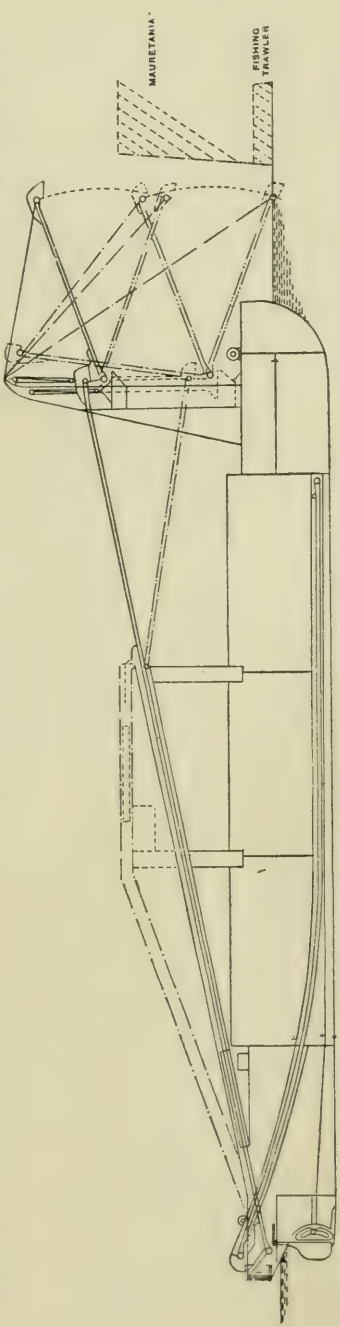


FIG. 13.—SELF-DISCHARGING VESSEL: LONGITUDINAL SECTION SHOWING THE ARRANGEMENT OF THE BELT-CONVEYORS AS FITTED TO COALING BOATS SUITABLE FOR DELIVERING BUNKERS OR CARGO TO LARGE OR SMALL CRAFT.

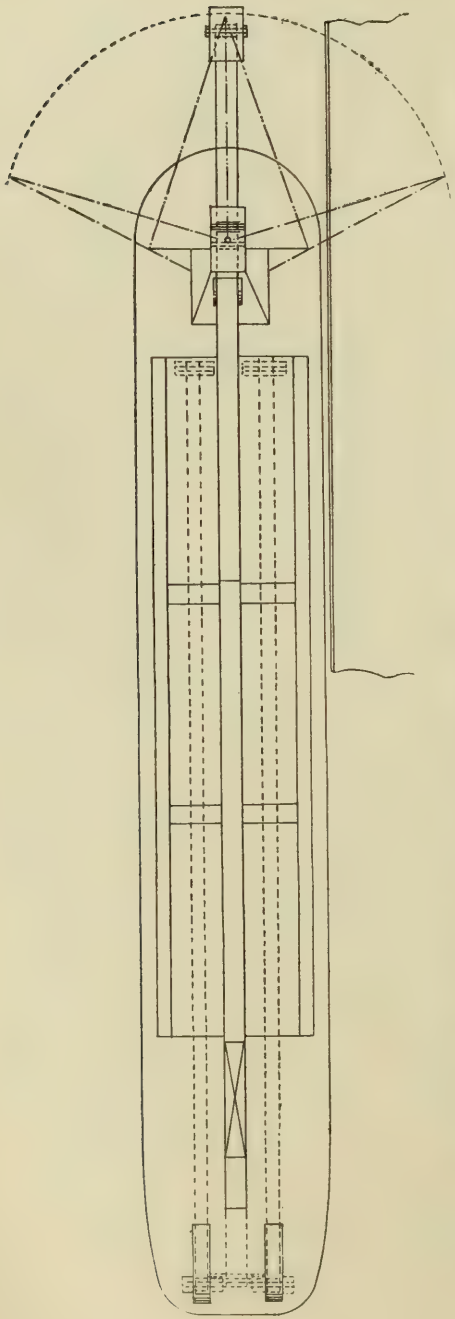


FIG. 14.—SELF-DISCHARGING VESSEL: PLAN SHOWING THE ARRANGEMENT OF THE BELT-CONVEYORS AS FITTED TO COALING BOATS SUITABLE FOR DELIVERING BUNKERS OR CARGO TO LARGE OR SMALL CRAFT.

The driving-engines are connected to the conveyors so that either can be run independent of the other, or both run together, the power being arranged to deal with a full load on both belts, delivering at the rate of 500 tons per hour. A 3,000-ton cargo can, therefore, be run out in 6 hours, or, allowing for stoppages in moving barges, etc., say, 7 to 8 hours, and this is done by one stoker, one engineer, two labourers in the hold, and two adjusting the booms into the craft.

The gear being placed as described, quite independent of the cargo, it is free to run empty, and is made ready and waiting to start before the vessel is moored and the barges in place; and this alone saves considerable time as against the rigging of derricks, platforms, and getting-baskets, etc., in the ordinary method.

The advantages to be derived from the adoption of this type of boat are many, including quicker despatch; and, consequently, harbour authorities operating coal-havens such as at Hamburg, will be able to deal with a much larger import in a given area. This ere long must come into consideration as against the possible necessity of increasing the accommodation of the haven. Barge-owners and also coal-merchants and consumers will reap great benefit, as there is no great fall in the discharge between the ship and the barge, wharf, or truck, and consequently there is a minimum of breakage or loss of weight. A very liberal estimate of the cost of discharge under such conditions will not reach the sum of 1d. per ton, and at this cost the cargo is also weighed, as the conveyors while passing through the poop are carried over automatic recording weighers, each giving the actual weight of cargo delivered.* Another, not by any means

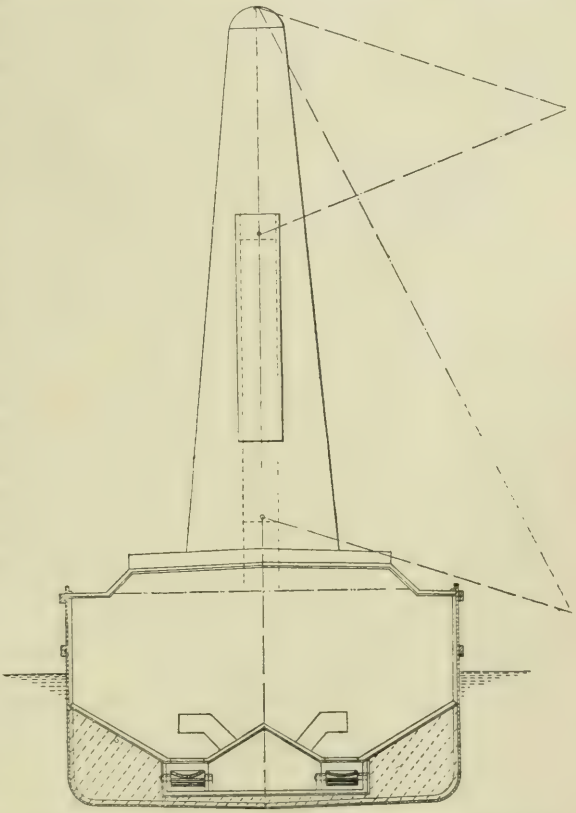


FIG. 15.—SELF-DISCHARGING VESSEL: SECTION SHOWING THE WORKING ARRANGEMENTS OF THE BOOMS OR SHOOTS WHEN DELIVERING BUNKERS TO LARGE OR SMALL CRAFT.

* For a description of this recording weigher (the Merrick conveyor weightometer), see Appendix II. to the writer's paper on "Coal-shipment and the Laying-out of Staithe Heads," *Trans. Inst. M. E.*, 1908, vol. xxxvi., page 725.

negligible, item is the cleanliness attained in the vessel and its surroundings, the coal all being under cover until its delivery into truck or barge. This makes the vessel somewhat free of delay under bad weather, as few men are exposed, the cargo is discharged in fine condition, and no disputes can arise as to weight in wet weather, etc. The whole arrangement places the steamer thus fitted up in a position of independence of shore labour, thereby avoiding the frequent delays arising from labour troubles. The number of men required being so small and the time occupied so short, it should be a simple matter to agree with the crew of the vessel that they will receive a fixed extra wage and that the discharge of the cargo be part of their duty. In some quarters it is anticipated that there may be some opposition to the adoption of this type of boat in certain trades—for instance, in the coasting and London trade, the latter trade from the Tyne and the Wear being the largest in the whole of the coasting trade. The custom has been, and exists at the present time, for the receivers to insist on discharging the cargo, thereby gaining some profit by so doing, this being stipulated among the terms of the charter-party at about 1s. 0½d. per ton (including weighing) for such work: and so the difficulty that may face this new type of vessel in its early days is that the receivers may insist on still discharging the vessel and charging their own terms for doing so, ignoring the apparatus that has been fitted up on board for this purpose. There is little fear, however, that should this self-discharging arrangement prove to be a success, any obstacles of this character will not be easily overruled.

Inventors have, for several years, been engaged in attempting to bring out a system of belt discharging, as applied in barges and such like; but until the advent of Mr. Doxford's patent, combined with that of Mr. Christensen's (of Messrs. Fraser & Chalmers, Limited), no belt-system had been successfully invented, as the inclined belt occupied so large a space in the hold of the vessel. In the system above-described, the incline is carried through the engine space, and consequently considerable greater cargo-carrying capacity is secured in this vessel as compared with what has hitherto been the case where the incline was through the hold, the enormous commercial difference being absolutely fatal in the case of the latter.

APPENDIX.

Several patents in connexion with belts for elevating coal from barges have been taken out from time to time, among others being the following :—

Wrightson, Thomas, Teesdale Ironworks, Thornaby-on-Tees, No. 27939, December 8th, 1896.

Conley, Owen James, 96, Broadway, New York, No. 2025, January 28th, 1899. This patent lapsed in 1908.

Woodruff, Cyrus Henry, 367, Linwood Avenue, Buffalo, New York, U.S.A., No. 10802, May 10th, 1902.

White, Thomas, Denbigh, Portsmouth Road, Woolston, Southampton, No. 19747, September 5th, 1906.

Holland, Alfred, 103, Manchester Road, Lostock, Gratam, near Northwich, Cheshire, No. 1336, January 18th, 1906.

Smulders, A. F., Schiedam, near Rotterdam, Holland, No. 14016, June 10th, 1906.

Christensen, Paul Frederick (Messrs. Fraser & Chalmers, Limited), 3, London Wall Buildings, London, E.C., No. 5015, March 1st, 1907.

Doxford, Charles David, Pallion Yard, Sunderland, No. 24261, November 2nd, 1907.

Ross, Charles Douglass, Milwaukee, Wisconsin, U.S.A., No. 2320, February 1st, 1908.

Mr. A. Munro Sutherland (Newcastle-upon-Tyne) wrote that the new collier, built by Messrs. William Doxford & Sons, Limited, for Messrs. B. J. Sutherland & Company, was launched last week. It was intended, before the vessel went to sea, to place coal on board, in order to thoroughly test the discharging apparatus, and if any of the members of the Institute were interested in the subject, and would advise him, he would see that they received an invitation to witness the experiments.

Mr. A. E. Doxford (Sunderland) said that he had nothing to say on the subject, beyond what was stated in the paper, except that the boat would be ready for trial in two or three weeks, and that the trials would take place on the Wear.

Prof. Henry Louis (Newcastle-upon-Tyne) asked whether Mr. Doxford could tell them the gradient of the belts, a point which was not stated in the paper.

Mr. A. E. Doxford replied that the maximum was 22 degrees, and, in reply to a further question as to whether any arrangements had been made for apparatus for preventing breakage of the coal in the loading of the new boats, said that the coal was loaded in the ordinary way. The patent did not apply to loading but to discharging, in which there was, of course, less breakage, there being no fall of the coal whatever.

Mr. P. F. Christensen (London) said that the subject of applying mechanical means for unloading cargo in bulk from ships was a problem which had been in his mind for a good many years. He had, however, not been able to make any headway with it until Messrs. William Doxford & Sons, Limited, took the question up, with the result that the first ship of this type was now launched, and would soon be ready for the proposed discharging experiments. There had been a good many points to consider, and while the present ship might not be the absolutely final type, he was convinced that they were on the right road. When one had material in any kind of receptacle, and could allow it to descend by gravity on to a system of conveyors which would deliver it to its final destination in a continuous stream, one could, of course, dispense with grabs and hand-labour. There were a number of cases where conveyors could be used in connexion with ships, and he would only mention that to coal, for instance, a big steamer with side-ports, the conveyor system could be used with great advantage. The intention was, in such cases, to build a central pontoon, fitted with a conveyor, which would be able to elevate the coal up to any required height, when it would be distributed, through a horizontal conveyor, to eight or ten shoots, which would discharge the coal simultaneously to each of the side-ports. Not more than 30 tons of coal would be delivered to each side-port per hour, that being the maximum amount which could be conveniently received and trimmed. The horizontal distributing conveyor would, of course, be adjustable vertically, in order that it could be arranged to correspond with the position of the side-ports of any vessel. It was also contemplated that a number of smaller barges could be used in connexion with the central elevator or pontoon, each being fitted with its own conveyor gear, which would receive motive power from a generating plant located on the central pontoon.

When first he (Mr. Christensen) commenced going into the question, he found that both shipowners and shipbuilders were very conservative; with them a ship was a ship, which must have certain lines that could not be changed; because as soon as this or that were changed, there was going to be trouble somewhere: and if the carrying capacity of the vessel was decreased, however slightly, both shipbuilder and shipowner objected.

He had a further idea that it might be possible to have more

adequate means for getting the coal forward from the bunkers to the boiler-room. He was sure that it was not impossible to do that. From his personal experience, he knew what it was to haul coal out of sometimes eight adjoining water-tight compartments; he considered that it was almost inhuman work, and he had seen strong men collapse through heat and exhaustion. Without doubt a solution of the problem would some day be found, and the whole of the coal would be brought forward from the bunkers to the boiler-room by mechanical means.

Prof. LOUIS said that he would like—as a man entirely ignorant on the subject—to ask the constructors a question. Glancing at the sections, it seemed to him that the effect was to lift the whole cargo a good deal off the bottom of the vessel; that meant that the centre of gravity would be considerably raised, and he would imagine that the ship would therefore probably lose some of its stability. He would like to ask whether his criticism was correct, and, if so, whether the point was being met at all.

With regard to Mr. Christensen's suggestion as to the mechanical transfer of bunker-coal along the vessel to the boilers, that was, to some extent, already being done. On one of the North-German Lloyd Atlantic boats, he had seen a couple of lines of rails laid along the whole length of the floor of the boat, and ordinary colliery tubs conveyed the coal from the bunkers to the stoke-holes.

Mr. W. DOXFORD (Sunderland) said that the point had received consideration, the proportions of the vessel having been adjusted to maintain the necessary stability.

Mr. H. M. WILSON (Newcastle-upon-Tyne) wrote that the cantilever-framed type of vessel was undoubtedly the best adapted for self-trimming, on account of the natural slope of coal from 40 to 45 degrees in relation to the topside ballast-tanks inner-shell slope. The turret type, with the latest improvements which increased the width of the turret to 60 per cent. of the maximum width of the vessel, was a close approach to self-trimming. The strength of the turret was undoubted, as when launching one of these vessels some few years ago she stuck in the ways, and was suspended over half her length; but

on examination in dock soon afterwards no alteration whatever was found in her keel.

The monitor type of vessel seemed to follow closely the turret build structurally, with the addition of the two wave-like projections on each side. The writer was present recently at the launch of the first vessel of that type, and was much struck with the designer's ideas and hopes. The vessel was 279 feet long, 42 feet wide, and 20 feet 7½ inches deep, and was of the single-deck type. Her deadweight was about 3,250 tons, and the extra hold capacity over other vessels of the same size, due to the projecting sides, was 100 tons—equal to over 3 per cent. increase. The power to drive a vessel of this size at more than 10 knots an hour was about 1,100 indicated horsepower, and it was hoped with this power to get 10 per cent. more speed out of this type, or 11 knots per hour, this increase being entirely due to the improved construction. It was to be hoped that she would fulfil all that was expected of her: and, if these hopes were realized, it would certainly revolutionize shipbuilding. In addition, the projections would tend to steady the vessel. She carried the usual hold-stanchions, and not (as shown in Mr. Kirsopp's diagram, Fig. 6) diagonal ties or struts between the deck-beams and frames. Being without sheer, she was as strong as the turret type, and was of similar construction. In a heavy sea on light load she was, however, transversely stronger, on account of the large corrugated sides of the hull.

Regarding rapid loading and unloading, the cantilever-framed type was regularly loaded by means of grabs at Montreal, Canada, at the rate of 1,000 tons per hour, which was pretty rapid. Allowing for gravity, as the height from which the material was dropped was not mentioned, the same vessel should be discharged about 25 per cent. slower, or at the rate of about 750 to 800 tons per hour. The belt-mechanism boat, built by Messrs. William Doxford & Sons, Limited, was expected to deliver from 500 to 600 tons per hour at the most, a quantity which seemed small in view of the advantages due to belt-conveyance. He would like information as to whether there was any means employed to prevent the coal from falling over the side of the belt, as, if not, such coal would be carried by the returning belt to the roller carrying the belt, and might cause

serious damage. There was also no information given as to the wear-and-tear of the conveyor belts, which would be considerable, as he understood the belts were made of indiarubber, about $\frac{1}{2}$ inch thick: and with average use, say carrying coal to Continental or Baltic ports, they could not last more than 6 months. With a vessel of 3,000 tons burthen, making a weekly trip, this would mean a new belt for about every 70,000 tons. What was saved in labour would not, he felt sure, meet the increased cost and upkeep of this belt and as much as would be needed to cover the extra machinery. If one knew the cost of the belt, then the comparative loss or gain could be ascertained. It seemed to him as though the cart was before the horse, and, instead of so much valuable space being occupied in the most useful part of the vessel, that something on the deck or on shore in the form of an improved grab would meet the case much better, whilst a Temperley transporter, or something similar, could be used for coaling at sea.

The Chairman (Mr. J. B. Simpson) proposed a vote of thanks to the writer of the paper, which they would have an opportunity of further discussing at their next meeting.

The vote of thanks was carried unanimously.

DISCUSSION OF MR. W. C. BLACKETT'S "NOTES ON A SMALL CONTRIVANCE TO MORE EASILY DETECT FIRE-DAMP."*

Mr. W. C. Blackett (Sacriston) said that he wished to apologize for having brought forward what some might think was a trivial matter. He would like them to understand that it was done for a definite reason. At that particular time, there was, and was now, a good deal of consideration being given by the Home Office to the question of introducing "standards" of ventilation, and there was a suggestion that a standard of some very small percentage of fire-damp should be adopted. He was anxious that the members should consider the whole subject, and he wanted to show that by very simple means—for which he claimed no novelty—increased facilities

* *Trans. Inst. M. E.*, 1909, vol. xxxvii., page 276.

for examining for fire-damp could be got in an every-day practical way, without the Home Office introducing highly scientific instruments or taking laboratories down the pit.

Referring to Messrs. John Cadman and E. B. Whalley's reports,* Mr. Blackett said that they went to show that there was an inclination to fix a small percentage—2 per cent.—as the standard for collieries. It struck him as an unreasonably small amount. He thought that everybody should form an opinion on the subject, and it was with this view that he brought his appliance forward. If anybody had tried it, he should like to hear his remarks concerning it. His own opinion was that anything less than 3 per cent. would be an unreasonable "standard," although that would depend upon what was meant by standard and what its purpose was.

Mr. J. H. Miller (South Hetton) said that, on behalf of Mr. W. O. Wood, of South Hetton, he wished to bring before the members a device—a "flame-reducer"—for the detection of fire-damp, which he (Mr. Wood) had had in use for 18 years. Mr. Wood did not pit it against Mr. Blackett's appliance, but merely as a matter of history he would like the members to see it. The appliance (Fig. 1, Plate XIV.), which was attached to an ordinary Davy lamp, consisted of a sleeve or tube (Figs. 2, 3, and 4) surrounding, and a little larger than, the wick-tube (Fig. 5). Sliding telescopically on the wick-tube, it was raised or lowered by a screw, *A* (Fig. 6), passing through a tube in the oil-vessel, in a similar way to the pricker, the screw engaging in a nut attached to the sleeve or sliding tube (Figs. 1, 2, 3, and 4). The wick was first adjusted by the pricker in the ordinary way, and then the sliding tube was raised slowly without any jerking, thus gradually reducing the flame. Mr. Wood had found that he could detect with this arrangement a smaller quantity than could be detected by the ordinary methods, in which there was a risk of losing one's light. In Mr. Blackett's contrivance, a large flame was used, while in Mr. Wood's device the flame was reduced.

Mr. E. Seymour Wood (Murton) said that he personally used a lamp such as that described by Mr. Miller, and he had found it

* *Royal Commission on Mines: Reports of an Enquiry into the Ventilation of Coal-mines and the Methods of Examining for Fire-damp,* by Messrs. John Cadman and E. B. Whalley, 1909 [Cd. 4551].

To illustrate Mr J.H. Miller's Description of the Wood Flame reducer for Detecting Fire damp.

FIG. 1.

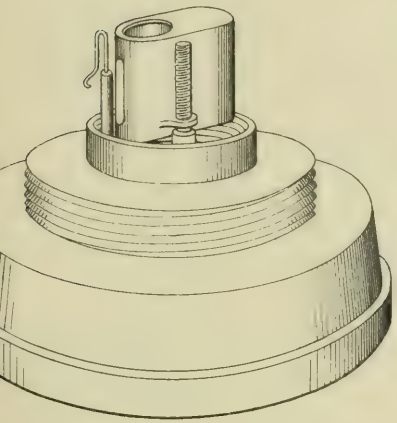


FIG. 2.

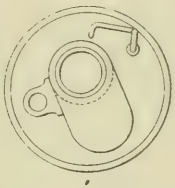


FIG. 4.

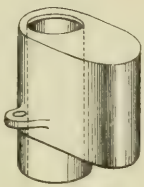


FIG. 5.

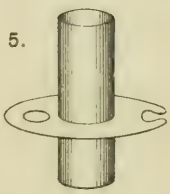


FIG. 1.—SHOWING DAVY LAMP, WITH PARTS OF APPARATUS IN POSITION.

FIG. 2.—SLEEVE OR SLIDING-TUBE WITH PRICKER IN POSITION.

FIGS. 3 & 4.—SLEEVE OR SLIDING-TUBE ON OUTSIDE OF WICK-TUBE.

FIG. 5.—ORDINARY WICK-TUBE.

FIG. 6.—DAVY LAMP, WITH FLAME-REDUCER REMOVED, SHOWING, A, SCREW USED FOR RAISING OR LOWERING SLEEVE.

The Figures are not Drawn to Scale.

FIG. 3.

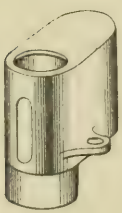
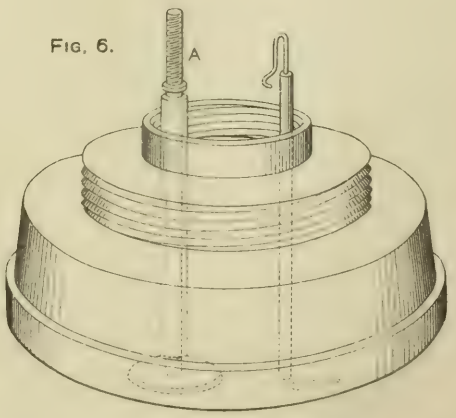


FIG. 6.



And.r Reid & Comp.y L.td Newcastle upon Tyne

very efficient. With it one got a small blue light, and there was no risk of losing the light. In the ordinary safety-lamp, when the light was brought down as low as possible, it might easily be lost, but with the present contrivance, one always felt comfortable when testing for gas.

Mr. W. C. Blackett said he thought it an excellent arrangement. At the first glance there appeared to be little difference between it and his own contrivance, save that the sleeve in Mr. Wood's device went right round the flame, while his shield only went round a portion of the flame.

Prof. Henry Louis (Newcastle-upon-Tyne) said that he considered that Mr. Blackett was not doing himself justice, as his (Mr. Blackett's) contrivance produced a bigger body of flame and a hotter flame. He thought that it was a perfectly well-known fact that fire-damp showed a cleaner cap and could be more easily detected by a large and hot flame. He thought that Mr. Blackett's principle was the better of the two. Mr. Blackett, at the same time, should, with his contrivance, be able to completely mask the white light.

Mr. W. C. Blackett, referring to the illustrations of his apparatus,* said that where only a blue cold flame was shown, a little cap was formed, and if some white flame was shown, a cap two or three times the length was obtained. It was a distinct advantage in that way, and with 3 per cent. of gas with a little white flame in the lamp, a cap about three times the height as against that with the small blue flame was got. It was suggested in Messrs. Cadman and Whalley's reports that "It was at once recognized that a definite standard height of testing flame must be adopted, and after many trials it was found convenient to use $\frac{1}{10}$ inch as the standard. With a carefully-trimmed lamp-wick it is possible to obtain a non-luminous flame $\frac{1}{10}$ inch high with any of the oils used."† It struck him as unreasonable to expect men to keep themselves and other people safe when going about delicately trying to get a blue flame $\frac{1}{10}$ inch high, as other dangers were then introduced.

* *Trans. Inst. M. E.*, 1909, vol. xxxvii., plate x.

† *Royal Commission on Mines: Reports of an Enquiry into the Ventilation of Coal-mines and the Methods of Examining for Fire-damp*, by Messrs. John Cadman and E. B. Whalley, 1909 [Cd. 4551], page 61.

Prof. Henry Louis said that Prof. Cadman had only stated that he did it himself in his own tests.

Mr. W. C. Blackett asked whether Mr. Wood would guarantee, from his point of view, that when he was looking for gas with a large flame snubbed by contracting the oxygen supplied to it, he would not produce any carbon monoxide in that process, which might show a cap of its own. He thought that perhaps one of the authorities on chemistry would be able to give them some information on that point.

Prof. P. Phillips Bedson (Newcastle-upon-Tyne) said that there was a possibility that by cutting off the oxygen and cooling down the flame carbon monoxide might be produced. He did not think, however, that a cap could be got in that way.

Mr. J. H. Miller suggested that that difficulty might be overcome by reducing the flame in the normal atmosphere, and observing the appearance of the flame, and then, when it was raised into the mixture of fire-damp, any change could be detected.

Mr. W. C. Blackett said that that was so, provided that pure air from which to raise it was underneath the mixture; but there were such things as returns filled with a percentage of gas, and one could not then raise it from one to another.

Mr. J. H. Merivale (Acklington) said that he had come to the conclusion that, although these contrivances were interesting —and he thought it wise to pursue the enquiries—he doubted very much whether it was possible to contrive any piece of apparatus whereby one could practically detect and define the percentage of gas in a pit. It was possible to say that there was gas, but he did not think that they could say what the percentage was.

APPENDICES.

I.—NOTES OF PAPERS ON THE WORKING OF MINES, METALLURGY, ETC., FROM THE TRANSACTIONS OF COLONIAL AND FOREIGN SOCIETIES AND COLONIAL AND FOREIGN PUBLICATIONS.

THE COAL-BASIN OF GUARDO, SPAIN.

Datos geológico-mineros relativos á la Cuenca Carbonífera de Guardo (Palencia). *By* R. S. Lozano. *Boletín de la Comisión del Mapa geológico de España,* 1906, *series* 2, *vol. viii., pages* 105-134, *with* 1 *figure in the text and* 1 *plate.*

From Valderrueda, in the province of León, where it is about 6¼ miles broad, a belt of Upper Carboniferous or Coal-measure strata extends into the province of Palencia, narrowing gradually from Guardo to Cervera del Río Pisuerga, where it disappears beneath rocks of later date. Taking into account all its sinuosities in the 19-mile stretch from Guardo to Cervera, one may still determine its general strike as east to west; the average breadth diminishes from barely 2 miles at Guardo to about 1,000 feet at Cervera. The Coal-measures consist of clay-slates, more or less crumbly and carbonaceous at the contact with the coal-seams, and sandstones, generally shaly and often containing plant-remains. On the north the Coal-measures abut against the high ridges of (Carboniferous) basement-quartzites and limestones; for the rest, the neighbouring rocks consist of Cretaceous sandstones, limestones, and marls, and later drifts of gravel and sand. The area is characterized by the general inversion of the strata, and by the plication which has resulted in the repetition of outcrops of one and the same horizon. The coal-bearing series is cut by several cross-faults, and there is a main fault dividing it from the Cretaceous. The plant-remains are mainly assignable to the Middle Coal-measures and the base of the Upper Coal-measures. There is every reason to believe that, within the mining concessions now in operation, the Coal-measures extend (beyond the outcrop) beneath the Cretaceous and the Drift.

Turning first his attention to the western portion of the coalfield, the author classifies the coal-seam in three groups: northern, central, and southern. It is in this portion that exploration-work has made the greatest progress; while, as regards the eastern portion, only conjectural data can be put forward. On the whole, it may be stated that the seams exhibit great irregularity in thickness, and that they are considerably interrupted by faults. The coal is black, lustrous, occasionally very hard, with a fracture which varies from conchoidal to foliated. Its average specific gravity is 1·65. It burns slowly with a pinkish, not very bright flame, gives off little smoke, and splits and decrepitates in course of burning. No less than fifteen general analyses, and twenty-three analyses for ash alone, are tabulated, the general result of which is summarized as follows:—fixed carbon, 84 to 93·16 per cent.; volatile matter, 2·89 to 9·82; sulphur, 0·88 to 1·01; hygroscopic water, 1·68 to 5·91; and ash, 2·98 to 7·75. The heating power ranges between 7,697 and

7,783 calories. By their chemical composition, as well as by their physical characteristics, these Guardo coals must be ranged among the true anthracites.

A detailed description is given of the Dos Hermanos, San José, Competencia, Alejandrina, Primera, San Abel, San Fermín, Coto San Claudio, La Verdad, and La Constancia mines, and comparative results of steam-raising experiments at the Barcelona Arsenal (the foreign coal used being "Cardiff" coal) are tabulated.

In the Dos Hermanos concession, the average thickness of the anthracite-seam is 3 feet; the coal is hand-picked, and also sifted, and its average cost-price delivered on truck at the Villaverde railway station is 5s. 6d. per metric ton (but, in reality, it is said to cost as much as 7s. 4d. per ton, when every factor is taken into account).

In the San Claudio mines plant-remains characteristic of the Middle Coal-measures and the lower portion of the Upper have been found. Here the measures are much folded and dislocated, and there are many variations in strike; but it may be said that the general strike is from north-west to south-east. Fire-damp has so far been conspicuous by its absence, both from these and from the neighbouring mines. As to water, no great influx is to be looked for in shafts opened within the Coal-measures; but, in sinking through the Cretaceous, explorers may reckon on meeting with considerable quantities. The cost-price of coal at the pit-mouth may be estimated at about 6s. 10d. per metric ton. At the time of the author's visit, the proportion of "small coal" to the total output was 63 per cent. L. L. B.

THE CUPRIFEROUS DEPOSITS OF NORTHERN PALENCIA, SPAIN.

Nota acerca de los Yacimientos cupríferos del Norte de la Provincia de Palencia. *By* R. A. de Yarza. *Boletín de la Comisión del Mapa geológico de España*, 1906, *series* 2, *vol. viii.*, *pages* 1-9.

The author states at the outset that the deposits which form the subject of this paper have failed to yield satisfactory results from an industrial point of view, and the attempt to work them has been abandoned; but they are highly instructive in connexion with the theories of the origin of ore-bodies. They occur at Carracedo, near Cervera del Río Pisuerga, in the province of Palencia. This is a region the tectonic structure of which is highly complicated by the conjuncture of the Hercynian and the Pyrenean folding. The rocks are principally limestones alternating with more or less siliceous clay-slates, contorted and upheaved, of Carboniferous age, traversed obliquely by masses of granite. Contact-metamorphism is most intense where the granite cuts across lime-bearing rocks; and the undoubted influence of the composition of the rocks, through which the igneous magma has forced its way, on that magma, is shown by the manner in which the granite in contact with the lime-bearing rocks becomes so charged with hornblende as to pass into a diorite, and occasionally into still more basic rocks. The granitic magma appears, on the other hand, to have "digested" or absorbed the clay-slates at the contact so effectually as to undergo but little alteration in composition. The cupriferous ores—pyrite, chalcopyrite, and phillipsite [*sic*], are invariably associated with the basic rocks in the contact-zone of the granite and the lime-bearing strata: the more hornblende these basic rocks contain, the more highly mineralized are they. Such ore-deposits may well be ranged under Von Groddeck's "Christiania type," where there is no question of the infilling of fissures, but it is plain that the hypogenic magma has partly

assimilated the immediately-neighbouring rocks. Now, as, in this case, the granite cuts obliquely across a series of steeply-dipping strata among which the slates predominate over the limestones, a considerable extension of the ore-bodies in the horizontal plane cannot be looked for. If mineralization were to continue in depth, along the contact of the granite with the lime-bearing strata, rich portions in some respects similar to certain chutes or lodes might be struck; but these Carracedo deposits conform with the law which practically everywhere obtains in regard to copper-ores—there is, namely, at no very great depth, a zone of enrichment of sulphides, beyond which great impoverishment supervenes and scarcely anything but iron-pyrites is to be found. This local enrichment is due to the reactions occurring between the poor sulphides of the deep levels and the oxidic minerals brought down by the waters percolating from the surface. The strictly cupriferous ores at Carracedo are chalcopyrite ($Cu\ Fe\ S_2$) and phillipsite (? phillipite) or variegated copper ($Cu_3\ Fe\ S_3$); and chemical equations are cited expressing the formation of these by the above-mentioned reactions.

The copper is supposed to have come up with the granitic magma, and the reasons for this hypothesis are assigned at some length. The lime in the limestones went to the formation of basic silicates, and the consequent liberation of carbon-dioxide in the gaseous condition must have absorbed heat and produced more rapid cooling at the contact of the magma with the limestones than at its contact with other sedimentaries; this, and the conditions of temperature and proportions of lime being such as to favour the crystallization of hornblende, must have produced exactly the combination of circumstances most appropriate for the precipitation of the sulphides of copper and iron.

L. L. B.

MANGANESE-ORES OF CIUDAD REAL, SPAIN.

Das Manganerzvorkommen in der Nähe von Ciudad Real in Spanien. *By* R. Michael. *Zeitschrift für praktische Geologie*, 1908, *vol. xvi., pages* 129-130.

The deposits here described at Ballesteros and Villafranca are very similar to the manganiferous ores from the Ciudad-Real district already mentioned by Prof. L. de Launay in his famous treatise on metalliferous deposits. The nearest railway-station to both localities is La Canada, 9 miles or so south of the provincial capital: the Ballesteros concession covers about 262 acres, and that of Villafranca (2½ miles farther east) only 62 acres. Exploration-work was initiated in the summer of 1907, and sixteen small shafts (in part only accessible) were put down. Very like in many respects to the manganiferous ores of the Caucasus, the deposits here opened up are bedded ore-bodies intercalated among practically horizontal strata (brown and reddish loams and clays) of comparatively recent date. They are, in fact, the outcome of the weathering and decomposition of the Tertiary basalts and associated tuffs that have broken through and overwhelmed the Silurian limestones which are the fundamental rocks of the area. Where the basalts actually crop out at the surface, the iron-ores assume greater, and the manganese-ores proportionately less, importance. It would seem evident that, in the course of the fluviatile erosion accompanying the decomposition and transportation of the materials of a given mass of basalt, the manganese was sorted out naturally and re-deposited in a concentrated form at some other spot. There is no question that the deposits, irregular as they are, but extending over a comparatively wide area, were laid down by rivers.

The winning of the ores will present on the whole but few difficulties:

the entire mass of clay, etc., from 10 to 40 feet deep can be removed by excavators, and the ores, after careful washing and picking, will be quite ready for shipping, the one desideratum being suitable connexion with the railway-line, a few miles distant. Eight analyses (made at British works) showed averages of 50 to 54 per cent. of manganese, 2 to 5 of silica, and 0·34 of phosphorus. Samples analysed in France yielded 49 to 54 per cent. of manganese, 6 per cent. of silica, and 0·21 to 0·25 of phosphorus. The ores invariably contain also from 0·14 to 0·37 per cent. of cobalt, and 3 to 4 per cent. of iron. It is believed that the amount of available ore will prove to be very large. A typical section shows, in descending order: 3¼ feet of arable soil; 6½ feet of reddish-brown loam; 8 inches of manganese-ore; 2 feet of reddish-brown loam, seamed with stringers of manganese-ore; 1 foot of grey clayey loam, with fragments of tuff; 4 inches of manganese-ore in lumps bedded in loam; and 13 feet of red loam (with concretions of manganese-ore) to the bottom of the shaft.

The country forms part of the plateau of New Castile, 2,000 feet and more above sea-level, and is traversed by the northern spurs of the Sierra Morena. The distances from La Canada railway-station to the sea-ports of Alicante, Cartagena, and Seville are respectively 271, 315, and 284 miles.

L. L. B.

METALLIFEROUS DEPOSITS OF CARTAGENA, SPAIN.

Die Erzlagerstätten von Cartagena in Spanien. *By* R. Pilz. *Zeitschrift für praktische Geologie*, 1908, *vol. xvi., pages* 177-190, *with* 8 *figures in the text.*

The metalliferous belt of Cartagena, broadly speaking, occupies a coastal strip some 3 miles wide along the Mediterranean, extending from Cabo de Palos and Mar Menor to Cartagena Harbour. It consists mainly of bare ridges, rising steeply from the sea to a maximum height of 1,450 feet, and sloping gradually northwards to a broad plain, walled in by the Sierra de Carascoy. The geological structure of the district is, in many respects, similar to that of the metalliferous region of Mazarrón, in the neighbouring province of Murcia. The basement-rocks are slates of varying character and composition, overlain by dark-grey highly siliceous dolomites, which are seamed with white venules of calcite and are of extremely variable thickness. The dolomites are the remnants of a vast formation, probably dating from the Muschelkalk epoch of the Trias, which at one time covered much of the south-eastern coastland of Spain; the slates are, in part at all events, of much greater antiquity, and were subjected to intense plication as far back as Carboniferous time. The formations just described are invaded by eruptive rocks, which originally welled out along a series of fissures trending east and west, in much the same direction as the Sierra de Cartagena itself now does. Among these eruptive rocks the andesites of Cabezo Rajado and Cabezo del Agudo are of greatest interest to the miner, as in association with them metalliferous lodes occur. There is, in fact, no doubt whatever as to the genetic relationship between the fissure-eruptions and the ore-deposits of the Cartagena district. The thermal waters characteristic of the moribund phases of vulcanicity found in the eruptive rocks themselves, as well as in the highly altered slates and dolomites, convenient sites for the deposition of the metallic particles which they carried in solution. Hence also a great variety in the form finally assumed by such deposits. These are classified, according to the ores which they yield, as (*a*) lead, zinc, and copper-ore deposits; (*b*) iron-ore deposits, manganiferous and non-manganiferous; and (*c*) tin-ore deposits.

According to their form and the nature of the country-rock, they are, on the other hand, divisible into (*a*) lodes in the eruptive rocks; (*b*) lodes at the contact between eruptive rocks, dolomites, and slates; (*c*) transverse or cross-veins and bedded veins in the slates; and (*d*) stock-works, lenticular, and bedded deposits in the dolomites. There is in places a distinct passage from one form of deposit into another. The mica-andesite mountain of Cabezo Rajado is, as its name implies, "furrowed" with the workings of the ancient miners, who seem to have devoted their attention to the argentiferous lead-ores and to the alunite resulting from the influence on the country-rock of the partly-decomposed pyrite. Similar deposits occur in the Gorguel district of the Sierra; but the area of which the highest summit of the Sierra, Cabezo de Sancti Spiritu, forms the centre, in regard both to variety of ores and to amount of output ranks perhaps first in the history of the Cartagena mineral industry. A detailed description is given of the great Manto de los Azules (or Blue seam), the extraordinary variable thickness of which ranges from $3\frac{1}{4}$ to well nigh 330 feet. The ores in the fresh condition consist of a mixture of argentiferous galena, zinc-blende, pyrite, and occasionally chalcopyrite. Stanniferous ores, the decomposition-product, probably, of stanniferous pyrite, occupy a fairly extensive area between the Cabezo de Sancti Spiritu and the Barranco del Avengue, and are worked in the most primitive fashion by a number of small lessees. There appears to be some relation between these secondary deposits and the secondary ores which occur at the hanging wall of the great Blue seam. It is noted that the iron-ores and argentiferous lead-ores of the Cabo de Palos have certain analogies with those of the Sierra de Almagrera (already described in these *Transactions*), but they have not as yet been thoroughly prospected. On the whole, the district affords a remarkable example of variety in character of deposits and of country-rock, concentrated within a comparatively small area.

After some considerations on the tectonics of the region, the author proceeds to give an account of the development and present state of the mineral industry of Cartagena. In ancient times great masses of ore lay near the surface, and were easily worked: hence there is nothing comparable in this district with the remarkable deep-level workings of great antiquity which have been discovered at Mazarrón. The author passes briefly over the medieval period, and dates the revival of the industry from somewhere about 1840. Its prosperity appears to have been for a time especially marked in recent decades, from 1890 onwards. In 1906, all the lead-ores got in the Cartagena district were smelted locally, and the yield for that year was 37,090 tons of metallic lead. Statistics of export, based on the Custom-house returns, are given for the years 1900 to 1907. The exports of calamine in the last-mentioned year averaged 20,000 tons, those of zinc-blende 100,000 tons, of iron-ores over 500,000 tons: tin- and copper-ores and pyrite play here a very insignificant part. There is withal a notable decrease of late years in the output of lead- and iron-ores, attributable in part to the exhaustion or impoverishment of the already-known deposits, and in part to the neglect of necessary exploration-work directed to untouched ore-belts, especially in the central and eastern portions of the Sierra.

Owing to defective legislation, the mineral-field was parcelled out into innumerable small concessions, worked at one time in the most wasteful fashion. Workings were quickly abandoned, and thus portions of the deposits, which could have been worked at a profit on a more methodic system, were lost to view for ever. Moreover, the inaccurate manner in which boundaries had been determined led to many disputes regarding ownership.

The general impoverishment of the ores, the diminution in depth especially of the lead-ores, the heavy taxation, the general rise in prices of material and of labour, the great cost of explosives (the manufacture of which is now a Government monopoly), are factors which do not conduce to a very optimistic forecast of the future of the mineral industry of Cartagena.

L. L. B.

MINERAL-DEPOSITS IN THE EARLY AND MIDDLE TERTIARY ROCKS OF SPAIN.

Minerales de los Sistemas Eoceno, Oligoceno, y Mioceno. *By* L. Mallada. *Memorias de la Comisión del Mapa geológico de España*, 1907, *vol. vi., chapter xiv., pages* 618-681.

The most important sulphur-deposits in the Peninsula occur among gypsiferous and bituminous marls of Miocene age, those which offer perhaps the greatest interest from the industrial point of view being found at Libros, Hellín, and Lorca.

Some 15½ miles south of Hellín (province of Albacete), near the confluence of the rivers Mundo and Segura, four distinct beds are worked, each again separable into four "seams" to which certain proper names or nick-names have long been applied. It is observed that, as the sulphur diminishes in thickness, the gypsum increases: on the whole, within a belt from 30 to 33 feet thick, the average workable thickness may be estimated at about 5 feet; but in the barren partings occur dispersedly crystalline fragments of sulphur termed by the miners *vejigas* (bladders). The mine is very nearly dry, as the clays among which it is opened up are impermeable; it is along the layers of gypsum that some water percolates through from the beds of the adjacent rivers. Finely acicular efflorescences of magnesian sulphate, occasionally forming "icicles" more than 12 inches long, abound in the workings. Sometimes there is so abundant an evolution of carbon dioxide (known as *tufo* to the miners) that operations have to be suspended, in the absence of any artificial system of ventilation. Upstream of the Segura, at El Cenajo, are some very promising sulphur-deposits, as yet but little worked.

The sulphur-deposits of Libros, in the extreme south of the province of Teruel, where it marches with that of Valencia, although of less importance than those just described, have been more or less continuously worked for over a century, and have yielded in some years more than 3,000 tons of sulphur. Here a certain band of gypsiferous marl is so constant an associate of the sulphur-deposit that the miners use it as a guide, and follow it up even when the sulphur itself appears to die away or nip out. So much of the sulphur as is disseminated in reniform masses within the gypsum is very pure (90 per cent. fine), but where it is commingled with the marls only half of the mass, or but little more, is marketable. The cost of freight and fuel has arrested the development of the industry here.

At Lorca, in the province of Murcia, two principal seams of sulphur, which have been more or less interruptedly worked since the middle of the nineteenth century, occur among clays, gypsum-bands, and sandstones of Miocene age. The mineral is variously found crystallized, in association with lamellar and fibrous gypsum; or in grains forming incrustations on the marls and clay; or again, in a pulverulent state along the joint-faces and bedding-planes. Atmospheric agencies have decomposed the beds into a whitish crumbly mass down to a depth of 65 feet or so, and within that belt of weathering the sulphur-deposits have undergone proportionate impoverishment; beyond it,

the rocks present their natural bluish-grey coloration and become richer in sulphur. Mention is made of several other sulphur-deposits in the same province, and also in the provinces of Alicante and Cádiz.

In Spain, the Tertiary strata vie with the Triassic in their wealth of brine-springs and rock-salt deposits. At Cardona, in the province of Barcelona, is perhaps one of the most important rock-salt occurrences in Europe: without any sign of bedding and 164 feet thick, it extends to unknown depths, but is so far divisible into two masses, the lower of which, white and very pure, though containing hyaline crystals with liquid inclusions, is worked. The upper mass is much mottled, owing to the presence of such impurities as metallic oxides, pyrite-crystals, carbonaceous particles, clay-venules, and gypsum. The rains have furrowed and carved this mass into a medley of *séracs*, recalling in its general aspect that of a glacier; moreover, solution has hollowed out of it many caverns, locally known as *bofias*. The deposit is worked opencast in a very cheap but perhaps wasteful manner, the annual output averaging 5,000 tons; by more strictly economic methods of working this could be enormously increased, without a doubt.

The salt-deposits of Suria occurs, like that of Cardona, among Oligocene strata, but has not been worked to a profit. In both localities, the springs are selenitiferous: hence it has been suggested that there is some relationship between these masses of rock-salt and the gypsum which is so abundant on both the northern and the southern flanks of the Pyrenees.

Among rugged ridges north-east of Perlata de la Sal, in the Province of Huesca, the waters of three brine-springs are collected into reservoirs between September and January. In the great heat of July, the collection of the salt begins, yielding perhaps 200 tons of salt, and a second collection is made in August, which yields somewhat less than the first.

In the neighbourhood of Remolinos, Torres de Berrellén, and Pradilla, in the province of Zaragoza, a rock-salt deposit consisting of layers 4 to 10 inches thick, between which are intercalated thinner layers of fullers' earth, occurs among gypsiferous marls and clays. It covers a considerable area, and the amount of mineral in sight is estimated at scores of millions of cubic feet. The purity, however, of the deposit is extremely variable, one and the same mine showing at one spot a perfectly colourless transparent salt, and at another spot a salt blackened by inclusions of gypsum and clay.

The salt-deposits of Villarubia de Santiago, in the province of Toledo, have been known from time immemorial, and more or less interruptedly worked down to the present day. They are exposed in a scarp some 300 feet high, rising above the left bank of the Tagus, among gently undulating marls and gypsum-bands of Miocene age, as two beds of rock-salt, the lower (6½ feet thick) being separated by about 20 feet of marl from the upper bed (50 feet thick). This last is overlain by a thickness of 33 feet of bduish thenardite (sodium-sulphate). It is only since 1871, when the rock-salt had been supposedly worked out, and the mine passed from the Royal Domain into private hands, that the idea seems to have occurred to anyone to make use of the splendid deposit of thenardite. As at Aranjuez, Minglanilla, and elsewhere, the deep-blue variety of rock-salt is common here: bands of an intense cobalt-blue twist and wind about within the colourless pellucid mineral. The cause of this coloration still remains a mystery, as none of the explanations offered have been found to accord with the known facts.

In the province of Alicante also, considerable masses of rock-salt occur beneath gypsum-beds of Tertiary age: and brine-springs in various other provinces of the Peninsula are enumerated.

Thenardite and glauberite are extraordinarily abundant in the gypsiferous marls of the Miocene lacustrine series. Either they originated from geysers neighbouring the Miocene lakes; or, admitting that these lakes were almost entirely surrounded by Triassic rocks, the saliferous springs from those rocks ultimately precipitated their contained salts in backwaters and lagoons, where the conditions favoured practical seclusion from the general mass of lake-water. The most important deposits of the kind in Spain occur about 2 miles west of Alcanadre, in the province of Logroño, cropping out among the gypsum-bands in the scarp overlooking the left bank of the Ebro, close to the railway-line. Their whiteness renders them conspicuous from afar, and they are only too easily weathered and dissolved away by atmospheric agencies. Similar deposits are described in the provinces of Burgos and Madrid.

Gypsum has already been mentioned more than once, and in fact it is of such frequent occurrence in the Spanish Miocene that even the official writer declares it impracticable to catalogue all the localities where gypsum is to be found. In the Oligocene and Eocene, the mineral is also of fairly wide-spread occurrence, but nothing like so abundant as in the Miocene.

There are innumerable deposits of lignite in the early and middle Tertiaries of Spain, but few that would repay working. In the province of Barcelona, lies the Eocene basin of Calaf, where at least eleven seams have been proved. They vary much in thickness, and yield two qualities of lignite: (1) a dull-black to greyish-brown mineral, burning with a dull red flame and much smoke, leaving a ferruginous ash with some sulphate of lime; and (2) a lustrous black mineral, burning with a long bright flame, less smoke than the former, and leaving less ash, although even then this amounts to 20 per cent. The average heating-power is 4,933 calories. These lignites are extremely pyritous, and liable to spontaneous combustion if stacked in the open. The basin extends for 8 miles from Sant Pasalás to Veciana, and 6¼ miles from Castellfollit de Llobregos to Prats de Rey. Between 1872 and 1881 the annual output averaged 6,700 tons. At Sanavastre and Llivia, in the province of Gerona, practically on the Franco-Spanish frontier, are some lignite-seams of considerable thickness, although perhaps not of first-rate quality. A sample of the mineral yielded on analysis 56·6 per cent. of volatile matter, 31·86 of fixed carbon, and 11·54 of reddish ash. A short description is given of the lignite-deposits of the Balearic Islands, and of other provinces.

As to asphalt, the only deposits of any consequence appear to be those in the province of Alava, where the Senonian sandstones and the overlying Nummulitic limestones are impregnated with asphalt. The San Ildefonso mine is described in connexion with these.

In metalliferous ores, the Tertiary system of the Peninsula is poor, and the author merely catalogues such occurrences as are known, as a matter of record. He devotes some 20 pages to an account of the mineral springs, the waters of which are available for medicinal purposes. L. L. B.

MINERAL-RESOURCES OF SPAIN AND PORTUGAL.

Die nutzbaren Mineralien Spaniens und Portugals. *By* Dr. Joh. Ahlburg. *Zeitschrift für praktische Geologie*, 1907, *vol. xv., pages* 183-210, *with* 8 *figures in the text and a key-map.*

Gold-mining, which flourished in ancient times, especially in the district that lies between the towns of Astorga and Villafranca in the province of

Leon and the northern coast of Spain, is now merely represented by the activity of a few Galician peasants who wash the auriferous river-gravels at Ponferrada, Palacois, and Salientes in the Vierzo valley, and by some insignificant placer-workings along the Tagus valley in Portugal. Spasmodic and unsuccessful attempts have been made in recent years to work again the placers of the Rio Genil, in the Granada plain below the southern wall of the Sierra Nevada.

Silver-ore deposits properly so-called are few in number, and most of the silver-output of the Iberian peninsula is derived from argentiferous lead-ores. Many apparently silver-ore deposits at the surface have proved in depth to be normal lead-ore deposits. Among such are the lodes of Guadalcanal, Cazalla, in the province of Seville, and Fuente del Rajo and Minaflores near Castuera in Badajoz: these, however, have yielded at shallow depths remarkably rich sulphides of silver. In some of the districts first mentioned, the mineral-industry dates back to the time of the Carthaginians, but recent attempts to revive it, so far as the silver-ores are concerned, have not met with success. Perhaps the richest argentiferous district in Spain is that stretch of the south-eastern coast which extends from the Cabo de Gata to the Cabo de Palos, north-east of Carthagena. Here are two distinct plumbiferous belts—the older carrying predominantly galena and blende poor in silver, the younger (probably of Pliocene age) carrying galena extremely rich in silver. These younger lodes appear to be genetically connected with a long range of Tertiary eruptives, and may well be termed true silver-ore lodes. As to Portugal, rich sulphides of silver are found only in a few isolated localities.

Lead.—Spain, which takes the second place among the lead-producing countries of the world, the first place falling to the United States of America, can boast an extraordinary number of plumbiferous deposits. About half of the total Spanish output is yielded by the district which lies in the north of the province of Jaen, on the southern flank of the Sierra Morena. Here is a poorly-irrigated high tableland, built up of Palæozoic slates broken through by innumerable intrusions of granite; four distinct groups of plumbiferous lodes strike through the rocks in correspondingly various directions, and all pitch very steeply. The thickness of the lodes varies from a few inches to 26 feet or more; a ton of 75 to 80 per cent. lead-ore contains at Linares from 11 to 16 ounces of silver, and at La Carolina and Santa Elena as much as 32 ounces of the precious metal. The workings at Linares have reached a depth of 2,300 feet or thereabouts, and, owing to increasing technical difficulties and the impoverishment (as regards silver) in depth, several mines have lately suspended operations. Much, however, might be hoped from the consolidation of many small concessions into one property, and from the introduction of the most approved modern methods, even if the workings were carried on at considerable depths. At Horcajo, in Ciudad Real, south-east of Almaden, a series of plumbiferous lodes very rich in silver (yielding as much as 161 ounces of silver per ton of lead) strike through the Silurian slates. The absence of troublesome gangue-minerals, such as heavy spar and pyrites, was another factor that favoured the miner; and so, when the industry was revived in the 19th century it soon attained a high pitch of prosperity, the annual output (even as late as the beginning of the nineties) averaging 70,000 tons of silver-bearing galena, but of late years it has diminished alarmingly. The output of the district between Cartagena and Almera, in the provinces of Murcia and Almeria, at one time raised it to the rank of the chief lead-producing centre of the world, but it has suffered a woful decline since the year 1898, when it still accounted for more than one half of the Spanish output.

Nevertheless, the author gives a fairly detailed description of the geology and mineral-industry of this metalliferous belt, the extent of which approaches 125 miles.

The lead-ore deposits of Portugal are of secondary importance in comparison with those of Spain, and they give no promise of greater consequence in the future. The deposits most worthy of mention are perhaps those that are still worked in the neighbourhood of Aveiro. Here galena, occasionally rich in silver, occurs in lodes that strike through Archæan and Cambrian slates which in places have been contact-metamorphosed by granite.

Zinc.—No ores of this metal occur in Portugal, and in Spain calamine is the chief zinc-ore, while blende has been found in large quantity in the south-eastern metalliferous belt above-mentioned (including Cartagena, Mazarrón, and the Sierra Almagrera). The neighbourhood of the first-named town at one time furnished a large output of calamine, and the workings round Almeria still yield a certain amount of that ore. In the province of Teruel, at Linares, a deposit of calamine attaining a maximum thickness of 42½ feet is worked in Mesozoic limestones, but by far the most important centre of the Spanish zinc-ore production is the province of Santander. The most considerable deposits here occur in the great Carboniferous Limestone range of the Cordillera Cantabrica, which attains an altitude of 8,200 feet above sea-level. Over an area of 6¼ miles in length and 1½ miles in breadth calamine is found in "nests" in the limestone, which is extensively dolomitized in the vicinity of the ore. The latter is very pure, and with it are associated, but in small proportion, lead and copper-ores and some rare streaks of cinnabar. In depth, undecomposel zinc-blende has been occasionally struck. The later group of calamine-deposits, extending eastward into the provinces of Biscay and Guipúzcoa, occur in Mesozoic, more especially Cretaceous Limestones. The output has diminished rapidly of late years, but this north-western region of Spain still accounts for the greater part of the zinc-output of the monarchy.

Chalcopyrite, etc.—It is hardly necessary to emphasize the fact that the district of Huelva is far and away the most important cupriferous district in Spain, and perhaps one of the richest copper-producing areas in the world. Of late years Mexico has been rapidly overhauling Spain in this respect. The ancients concentrated their attention on the extraction of the copper, but it is well known that nowadays the sulphur is practically of equal industrial importance. Until quite recently, the Huelva output was absorbed by the export-trade; but, the Spanish Government having levied an export-duty on copper-ores, the tendency is now to extract the copper from the richer ores on the spot, exporting the residues for the purposes of sulphuric-acid manufacture in other countries. The other cupriferous deposits of Spain and Portugal are briefly catalogued.

Mercury.—Although at Almaden, Spain can boast the richest quicksilver-deposit in the world, she has to yield the first place in the matter of output to the United States. At Almaden the ore, predominantly cinnabar, occurs among the Devonian sandstones of the southern spurs of the Sierra Morena. Mining operations were begun here as long ago as 400 B.C., and, after many vicissitudes, the mines are now in the hands of the State. A statistical table shows how extraordinarily rich are the Almaden ores, in comparison with those worked in any other part of the world, in the proportion of something like 17 to 1.

Iron-ores.—In the richest iron-ore district of Spain, the province of Biscay, the approaching exhaustion of the deposits can be foretold; nevertheless,

although other areas are of secondary importance, it can hardly be said, even now, that the kingdom is likely to suffer from any deficiency of such ores. Indeed, the iron-ore deposits are so numerous, and in many cases so advantageously situated as regards shipping facilities, that the iron-ore export from Spain continues to increase steadily. In this respect, Great Britain is still the best customer of Spain. The Bilbao and Santander ores are briefly described, with the accompaniment of statistical tables. The province of Lugo, of late years, has begun to play a considerable part in the total output. It yields magnetites and hæmatites which occur among crystalline schists.

A short description is given of the ferruginous deposits of the provinces of Seville and Badajoz. In both these provinces, the ores are magnetite and hæmatite; most of the mines in the province of Seville are in British hands. In Badajoz the ores occur as lenticular masses in crystalline limestones, and are primarily of metasomatic origin. The provinces of Malaga and Granada boast a great number of magnetite-deposits, the country-rock being in some places crystalline limestone, and in others gneiss, mica-schist, and serpentine. Those ores that occur among the limestones are doubtless of metasomatic origin; those that occur among the serpentines are probably the outcome of magmatic segregation; and finally, those that occur among the gneisses and mica-schists may have originated from contact-metamorphism. In the province of Almeria pockets and beds (10 to 16½ feet thick) of manganiferous brown hæmatite occur in crystalline limestones, or between these and the underlying crystalline schists. The ore is evidently the decomposition-product of metasomatically formed siderite-deposits, some of which have been indeed struck at greater depths. The deposits of iron-ore in the Sierra de Cocon and the Sierra de Medio, west of Almeria, are perhaps not so rich as those just described; but there is a vast amount of ore in sight, and a brilliant future lies before the mineral-industry of that district. The Mazarrón and Cartagena deposits, formerly of great importance, are approaching the limit of exhaustion. Immense deposits of hæmatite occur at Almohajo and near Teruel in Aragon, also at Berga in Catalonia. Detailed statistics are given of the output and export of Spanish iron-ores.

In comparison with the Spanish iron-ore deposits, those of Portugal sink into insignificance. It will suffice to mention the hæmatites of Moncorvo on the Douro, in the province of Traz-os-Montes, which occur as great lenticles among Laurentian gneisses. It is said that 51,000,000 tons of ore containing 40 to 60 per cent. of metallic iron are in sight; these ores are easily worked opencast, and transport-facilities are afforded by the Douro Railway on the spot.

Manganese.—The most important manganiferous deposits in Spain occur in the widely-distant provinces of Huelva and Asturias. Those of the former province are associated with the same belt of Palæozoic rocks as the world-renowned pyritous ores. Rather more than a hundred great lenticles of pyrolusite or, as the case may be, psilomelane, have been proved in Southern Spain and Southern Portugal, but they do not go down to any considerable depth. Nevertheless, the deeper-lying carbonates (into which the oxides pass below 300 feet), despite the fact that they only contain from 38 to 40 per cent. of metallic manganese, have found ready purchasers of late years. In Asturias, the ores occur in the form of lodes, the most considerable deposit being situated some 62 miles west-south-west of Santander, and 18½ to 20 miles south of the seacoast towns of Llanos and Riva de Sella. Here a lode some 10 to 13 feet thick pitching almost vertically is found on the northern

flank of the Picos de Europa, and may be followed along the strike from east to west for about 20 miles. The ore is a very pure pyrolusite containing, on an average, 58 per cent. of metallic manganese.

In Portugal manganiferous ores are practically restricted to a belt about 25 miles long from Mertola to Grandola, which is in all probability a prolongation of the Huelva metalliferous belt.

Tin.—In the matter of stanniferous ores, Spain has to yield precedence to Portugal. Here lodes occur in gneiss, close to a granite-junction, but do not continue into the granite; they are sufficiently rich to repay working, and yet have failed in some measure to attract the attention of the capitalist. It is true that the deposits are, for the greater part, situated around Braganza in wild and all but inaccessible mountain-districts.

Tungsten.—In wolfram-ore, Spain resumes her customary position of "mineralogical superiority" over Portugal. Wolframite is an associate of the Spanish tin-ores, and also occurs in quartz-reefs in various localities.

Very little importance attaches to the *nickeliferous* and *cobaltiferous* deposits of the Peninsula. *Arsenical* ores are worked both in Spain and in Portugal. The latter country alone possesses *antimony*-ore deposits of considerable extent, and they are gold-bearing. But the output of such ores in both countries is on the downgrade.

Coal.—In comparison with their other mineral-resources, Spain and Portugal are certainly poor in coal. The total amount of coal in sight in the former kingdom lies between 3,000 and 3,500 million tons, the annual output averages 3,000,000 tons, and the import amounts to about as much again. The province of Oviédo alone accounts for more than half of the total output. A brief description is given of the Asturian coal-basins, and it is pointed out that the high percentage of sulphur which the Asturian coal contains forbids its utilization for metallurgical purposes. South of the Sierra Cantabrica lie the coalfields of the provinces of Leon and Palencia; in the former more than twenty coal-seams have been proved, the character of the mineral varying from "meagre" to semi-bituminous. The other coal-bearing districts of Spain are of comparatively small importance (Seville, Cordoba, Ciudad Real, and Gerona).

Lignite-deposits are especially frequent in the great Cretaceous and Tertiary basins of Eastern Spain (Barcelona, Teruel, etc.). Detailed statistics of output and import of coal and coke are given.

True coal has been proved at three localities in Portugal, perhaps the most important of which is Vallongo, north-east of Oporto, where a narrow steeply-folded basin occurs, striking from north-west to south-east among Devonian and Silurian strata. "Owing to the contact-metamorphism induced by the closely neighbouring granite, the greater part of the coal has been altered into anthracite."

Nowhere does *graphite* occur in workable quantity.

Rock-salt.—A great deposit of this mineral occurs at Cardona, 56 miles north-east of Barcelona. It is actually worked opencast in the cliff-faces along the Rio Cardonaro, and the deposit has been proved over a radius of 2½ miles and down to a depth of 500 feet.

A little space is devoted by the author to jet, apatite, phosphorite, marble, alum-rock, glauberite, native sulphur, and celestine.

L. L. B.

PLUMBIFEROUS DEPOSITS OF THE SIERRA NEVADA, SPAIN.

Nota referente à varios Yacimientos de Minerales de Plomo de la Vertiente septentrional de Sierra Nevada. *By* R. S. Lozano. *Boletín de la Comisión del Mapa geológico de España*, 1906, *series* 2, *vol. viii.*, *pages* 25-34.

The Sierra Nevada is an enormous mass of more or less micaceous schists rising to an altitude of 11,500 feet above the sea, against which abuts a succession of folded, dislocated, and upheaved Cambrian and Triassic sedimentaries. It is in these sedimentary rocks that most of the metalliferous lodes of the region occur, those which bear lead-ores having been the main object of prospecting and exploration-work, etc.

At a height of nearly 4,600 feet above the sea, among the spurs of the northern flank of the Sierra Nevada, in the districts of Quentar and La Peza of the province of Granada, are situated the Virgen del Carmen and Encarnación mines, in the neighbourhood of the township of El Tocón. Several mountain-torrents course through this area, and already provide motive power for flour-mills. There is a middling bad road to the railway-station of Guadix (on the line from Linares to Almeria) 16 miles or more away. The concession of Virgen del Carmen was pegged out in 1900, and most of its northern portion is occupied by Triassic limestones, while in the southern portion these have been denuded off, laying bare the Cambrian micaceous slates, quartzites, and limestones, the Triassic appearing again, however, beyond the Palæozoic core of the anticline. The lead-ore is chiefly concentrated in the silicified limestone along the axis of the anticline, which is positively a line of fracture or fissure, on either side of which limestone (some 33 feet thick) appear the similarly Cambrian pink quartzites and slates. The ore-deposit belongs to the category of bedded veins. At the contact of the Triassic magnesian limestones with the Cambrian there are some deposits of galena, which do not, however, appear to be of much importance. Assays of the ore from the main deposit, an extremely fine-grained galena, in a gangue of quartz and calcite, showed from 58 to 76 per cent. of metallic lead and 3·04 ounces of silver per ton. The author made an assay of ore, got from a small mineralized belt associated with the Triassic limestones, and found that it yielded 63 per cent. of lead and 3·52 ounces of silver per ton.

The entire area of the Encarnación concession lies in grey magnesian limestones of Triassic age, with an east-to-west strike, and an average dip of 48 degrees northwards. The ore is a very fine-grained galena, occasionally foliated or laminated, occurring in lodes and also in pockets, in a gangue of silicified magnesian limestone. Assays have yielded from 78 to 82 per cent. of metallic lead and 4·32 ounces of silver per ton. The workings were conducted on a very mean scale, and, conceding the possibility of the extension of the deposit, there appears to be some prospect of good results attending operations conducted on an adequate scale.

About 2½ miles south-east of the township of El Tocón and 11 miles or so east of Granada is the Matilde concession, including a ridge which attains an altitude of 11,200 feet above sea-level, and the plateau of Los Lastonares, honeycombed with ancient mineral-workings. Here are magnesian limestones, variously compact and cavernous, of Triassic age, but little dislocated, and exhibiting no very steep dips. The galena occurs in irregularly dispersed pockets enveloped in red clays; it is in places foliated and in places fine-grained, and assays have yielded 77 per cent. of metallic lead and 2½ ounces of silver per ton. L. L. B.

STANNIFEROUS DEPOSITS OF PONTEVEDRA PROVINCE, SPAIN.

Nota referente á varios Yacimientos de Estaño de la Provincia de Pontevedra. *By* R. S. Lozano. *Boletin de la Comisión del Mapa geológico de España*, 1906, *series* 2, *vol. viii.*, *pages* 11-24.

Although the Galician tin-ore deposits appear to have been known and more or less worked from time immemorial, the tin-mining industry has never attained adequate importance in that region. The deposits with which the author deals are comprised within four concessions, near the boundary between the provinces of Pontevedra and Orense, in the neighbourhood of Lalín and Forcarey, in a fairly mountainous well-watered country, which lies at an average level of 1,640 feet above the sea. The water-supply locally available seems to be sufficient, both for washing the ores and for use as motive power. A great area of crystalline schists (gneiss, hornblende-, mica-, talc-, and chlorite-schists) rimmed round by granites, extends from Lalín in Pontevedra to Carballino in Orense, for 25 miles from north to south, and for well nigh 22 miles from east to west; it is among these rocks that the stanniferous deposits occur. With the last-named is intimately associated a younger white-mica granite, traversing in the form of dykes all the other rocks described. The "stanniferous granulite" is found in lodes of variable thickness, wherein the felspar is mostly decomposed into kaolin, and can thus be scooped out with comparative ease, yielding a mass of quartz-granules, flakelets of white mica, and kaolin, enveloping dark-grey granules of cassiterite, and such other accessory minerals as mispickel, tourmaline, and (occasionally) wolframite. Sometimes venules of quartz ramify through a lode or course parallel with it, and they are frequently accompanied by cassiterite. If the kaolinization of the lodes is proved to continue to great depths (and, so far as investigation has hitherto gone, this appears to be the case), the extraction of the tin-ore will be proportionately cheap. Apart from the lodes just mentioned, there are veins of white quartz in which are irregularly dispersed nodules and crystals of grey and somewhat translucent cassiterite: these quartz-veins are much thinner than the granulite-lodes, and are of much less industrial importance.

Some details are given of the Andorra and Andorra Segunda mines, also the Gloria and Purísima Concepción mines. Neighbouring the Gloria mine are other concessions yielding wolframite and cassiterite, which a British company has taken in hand; but, apart from the activity of our countrymen in this area, prospecting and exploration-work so far appears to have been conducted on a very small scale. The extent and number of the lodes have not been definitely determined; assays of crude ore have yielded from 0·96 to 1·86 per cent. of metallic tin, and consequently the ores must undergo some sort of mechanical concentration, or be locally smelted, to render them marketable.

Between 1887 and 1891 the price of tin-ore rose to such an extent that various foreign syndicates (English and Dutch among others) were formed to work the Galician deposits. They started with a "grand flourish" of modern methods, but were ultimately obliged to revert to the "antiquated system" in vogue in the district, and, a fall in the price of tin supervening, they suspended operations. The author draws two conclusions: (1) that the Galician deposits are only workable when the price of the metal is high; and (2) that the dressing of the ore is subject to very serious difficulties, which do not appear yet to have been overcome. At all events, stanniferous deposits, no richer than those here described, are being successfully worked in other parts of the world. L. L. B.

COAL-MINES, ETC., OF SOUTHERN YUNNAN, CHINA.

Résultats de la Mission géologique et minière du Yunnan méridional (Septembre 1903-*Janvier* 1904). *By* H. Lantenois, — Counillon, H. Mansuy, R. Zeiller, *and* L. Laurent. *Annales des Mines*, 1907, *series* 10, *vol. xi., pages* 298-383 *and* 385-503, *with* 1 *figure in the text and* 5 *plates.*

The first-named author (with the second and third as his assistants) was entrusted by the Governor-General of French Indo-China with the mission of investigating certain mining conditions on which would depend the definite choice of a route for the projected railway from Lao-Kay to Yunnan-sen; the two last-named authors supply notes on the fossil plants brought back by the expedition.

A sketch of the physical geography of the region lying between Mong-Tse and Yunnan-sen is followed by a description of the strata, illustrated by twelve sections and based on at least as many traverses. The rocks include (1) Lower Cambrian finely foliated, frequently gritty shales, among which are often intercalated bands of grit and occasionally massive beds of limestone, the whole series betraying no sign of metamorphism; (2) Middle Devonian massive greenish and yellowish-white limestones, with another facies distinguished by alternating shales and limestones among which grits are sometimes intercalated; (3) Upper Devonian grey or pinkish alternating limestones and shales, with a few grits; (4) Carboniferous deposits consisting, in descending order, of well-bedded massive blackish limestones (originally at least 1,300 feet thick), of grits, gritty shales, and a few subordinate limestones: the fossils were all obtained near the junction of the massive limestones with the underlying gritty shales, and in the vicinity of the coal-seams which are themselves associated with very characteristic reefs of dolomitic limestone, coral-limestone, and nodular limestone (Mr. Lantenois believes that the massive blackish limestone is of Uralian age); and (5) Permian white, occasionally yellowish saccharoidal limestones, overlain somewhat unconformably by red conglomerates and grits. The actual junction of the Carboniferous with the Devonian on the one hand, and with the Permian on the other, has not been precisely determined. All these Palæozoic strata have undergone considerable plication; and attention is drawn to the great Lu-Nan fault (extending over a distance of at least 50 miles from north to south), and to the parallel Lan-ni-Tsin fault, on the east of it, both having a minimum downthrow of 2,600 feet. On the whole, Mr. Lantenois believes that there is a stratigraphical gap between the Lower Cambrian and the Middle Devonian, a similar lacuna between the Upper Devonian and the Uralian, and that the overlap begun in the Uralian age continued during the Lower Permian, extending from west to east. The great tectonic disturbances around Lin-Ngan have brought the Middle Devonian directly against the Lower Permian. A description is then given of the Mesozoic rocks, apparently represented only by the sometimes mottled grits and shales and massive blue limestones of the Middle Trias, and by the limestones, grits, and shales of the Upper Trias. But, among the latter, at Ni-u-Ke are coal-seams to which a Rhætic age was assigned by Mr. Leclère on account of their similarity to other coal-seams of Yunnan, which are undoubtedly Rhætic. The plant-impressions collected by the expedition at Ni-u-Ke are not sufficiently well preserved to admit of a precise determination of their age. The Tertiary and Quaternary deposits include grey and greenish lacustrine marls and grits (among which are intercalated bands of lignite ranging in thickness from 3¼ to 65 feet or more), fluvio-lacustrine gravels and sands slightly compacted, and travertine limestones.

Among the igneous rocks are granites, labradorite-melaphyres and perhaps other basalts, etc.

In the third chapter, the geology of the region lying between Lao-Kay and Mong-tse is described, the evidence of intense metamorphism being perhaps its most characteristic feature. Coming then to the lignite-mines, Mr. Lantenois describes those of Mi-La-Ti and Pe-She-Gai, where two groups of workings operate on a single basin of lacustrine blue marls, almost entirely surrounded by the Carboniferous limestones. The seam has a very noticeable dip near the rim of the basin and a thickness of 5 feet, while in the middle it lies horizontal, and is said to attain a thickness of 40 feet. The Mien-Tien and Pe-Kia-Chwang mines work by means of numerous shafts, in the winter and spring seasons, a seam about 3¼ feet thick; and at Si-Chwang, where the Lin-Ngan plain now occupies the site of an ancient lake, a 16-foot seam of lignite, of less fibrous character than those previously mentioned, is worked by means of shafts 100 feet deep. At Pu-Chao-Pa opencast workings operate on a seam of brown lignite, about 65 feet thick, with numerous intercalations of very hard *Planorbis*- and *Paludina*-marls. Here the annual output amounts to some 2,000 tons; and the lignite is sold on the spot at a price equivalent to 7½d. per ton, but the cost of transport, etc., to Haiphong would bring its price there up to 15s. or 17s. per ton, and thus make it practically unsaleable. For this, apart from other reasons, the Yunnan lignites are and will remain of purely local interest.

With regard to coal-deposits of Carboniferous age, those of Tong-Hai are actively worked in three groups. The workings appear to be of ancient date, and have gone down fairly deep. The coal, occurring only in one seam, varying from 8 to 40 inches in thickness, lies among shales and grits which are themselves an intercalation in a great series of black limestones. It is used up locally in brick-kilns and smithies. At Pe-Chen are outcrops which may possibly prove to be of considerable extent. Mining operations are fairly active in the Kwen-Yang district: workings started as recently as 1901 deal with four seams overlying one another at intervals of 13 to 16 feet, and still higher up is a fifth seam of good appearance, as yet untouched, at least 3¼ feet thick. The Hai-Kiu deposits in the same district are practically horizontal, and the outcrop may be followed for several miles: they have been worked locally on a very small scale, but even those workings were abandoned at the time of Mr. Lantenois's visit. Some 18½ miles west and an equal distance north of Y-liang are two groups of workings which probably are operating on the same band of Coal-measures: the output from the Tsi-Tien group is small, and is used only for burning lime; that from the other group, the workings of which (ancient and modern) are ranged along the outcrop for about 3 miles, is nearly all converted into coke which is despatched to Yunnan-sen.

The Ni-u-Ke deposits, either Upper Triassic or Rhætic in age, are at a distance of about 6¼ miles from the track of the projected railway, and are said to include four seams with a total thickness of 10 feet of coal. They are actively worked, and the output is used up in brick-kilns. The Tu-Tsa and Mi-Lö deposits, of Triassic age, are distant two days' journey across rugged country, from the track of the projected railway. Only one seam apparently has been struck, varying in thickness from 32 inches to 5 feet. It is actively worked, and the output is converted into household coke.

Twenty-seven chemical analyses of the above-described coals are supplied, and it is noted that the universal tendency of the Yunnan coals to crumble into "small" is a serious defect. This friability in a measure vitiates all

estimates of the proportion of ash in the coal and of the calorific power. The methods of working are, of course, unsatisfactory from the European standpoint. As to the future that lies before the Yunnan coal-mines, the full development of which they are possibly capable will only be realized when it becomes practicable to place their output on the Hongkong market in competition with the coal of Japan and the coal of Australia. Certain of the Yunnan coals, if mixed with Japanese and Tongking coals respectively, would enhance the value of these for boiler-firing purposes.

A brief description is given of the copper-mines, many of which are now abandoned; and this is followed by a chapter on the iron-mines. Mr. Lantenois visited those that are situated among the Carboniferous quartzites and limestones (more or less metamorphosed by granitic intrusions) west of Si-Ho.

The palæontological and palæobotanical evidence adduced in the notes of Mr. H. Mansuy, Prof. R. Zeiller, and Dr. L. Laurent, confirms generally what has been already said as to the age of the rocks described. L. L. B.

JADEITE-DEPOSITS OF UPPER BURMA.

Die Jadeitlagerstätten in Upper Burma. *By* A. W. G. Bleeck. *Zeitschrift für praktische Geologie*, 1907, *vol. xv.*, *pages* 341-365, *with* 6 *figures in the text and* 2 *plates.*

This memoir embodies the results of the investigations conducted by the author in the course of an eight weeks' journey to the jade-mining district in the early part of 1907, and is preceded by a bibliographical list comprising sixteen entries. The district lies on the northern frontier of Upper Burma, and is of a highly mountainous character; it is watered by three considerable rivers, which are in parts navigable and yield an abundant water-supply even in the dry hot season. A brief preliminary description is given of the traverses made by the author, and it is incidentally noted that at Tawmaw the jadeite occurs in rock-masses worked both opencast and underground by the Kachins, a tribe of Mongolian origin which inhabits these mountains. At Hwéka, great quantities of jadeite-pebbles are extracted from a conglomerate; while at Mamon similar pebbles occur in the Uru river-gravels, especially in the deposits along the steep bank of the river. On the return-journey to the mining administration's headquarters at Kamaing, the author took the opportunity of spending a few days at Naniazeik, in order to examine the ruby-deposits there. The impenetrability of the primæval forest, the inadequacy (to use a mild term) of the tracks and paths, the scarcity of pack-animals, and the treacherous disposition of the warlike Kachins, constitute formidable obstacles to geological research in the region here described.

Of the three principal jadeite-deposits, that of Tawmaw is by far the most interesting from the petrographical point of view. The workings extend for about 670 yards from north to south, and their greatest extension from west to east is about half that. About twelve shafts have been sunk, attaining a maximum depth of 165 feet; the mineral is got by the old method of "setting fire to the rock." Tawmaw lies on a plateau some 3,300 feet above sea-level, and is 70 miles distant from the railway-station at Mogaung by the nearest road. At Hwéka, the conglomerates from which the jadeite-"pebbles" are extracted from a hill some 2,000 feet high north of the village; the whole face of this hill is cut up into quarries, and sometimes blocks of jadeite are found measuring scores of cubic feet. The unwholesomeness of the climate during the rainy season and the flooded condition of the country forbid mining operations from June to December or even later; the Tawmaw workings are

not completely drained of water until about March, and thus under the most favourable conditions jadeite can only be got during about three months of the year. About the beginning of March the Chinese flock into the country in thousands, with the view either of digging for jadeite themselves or of purchasing the available supplies of the precious mineral. Practically the whole of the output finds its way to China, none of it being worked up on the spot. There seems to be little doubt, indeed, that it is from the diggings and quarries of Tawmaw and Hwéka that the Chinese now derive most of the jade used in the arts in their country.

A general sketch is given of the geology of the district, so far as it has been found possible to ascertain it. The country stretching from Naniazeik southwards and westwards along the left bank of the Indaw river consists of granite, which has marmorized by contact-metamorphism certain limestones said to be of Carboniferous age: these marmorized limestones are undoubtedly the true matrix of the rubies obtained from their detritus at Naniazeik. Some distance north-west of that locality serpentines come on, and extend uninterruptedly through Nanion and Kansi to the Sanka river; with them are associated some comparatively small patches of picrite-porphyrite. South of Nanion and the serpentine-area lies a vast thickness of bluish-grey conglomerates and sandstones which are said to be of Miocene age: they extend presumably far to the south beyond Hwéka, and between them and the above-mentioned granites and marmorized limestones on the east long tongues of felspathic basalt are said to intervene. West of the Miocene sediments, serpentine recurs, covering all the country along the left bank of the Uru southwards from Mamon; between that locality and Houngpa terrace-like deposits of pseudo-lateritic brown hæmatite face the river. Between Seikmo and Lonkin farther north along the Uru is a small complex of crystalline schists, and west of Lonkin on the opposite bank of the river, the jadeite-bearing serpentine-massif is mantled over by "crystalline schists." The serpentine forms characteristic long steep ridges, generally capped by narrow plateaux, and seamed by deep-cut, gorge-like valleys. A small quantity of gold is got from washings along the Uru river at Lonkin, and some too, is found in the alluvia deposited along the steep-river-bank at Mamon. A considerable percentage of chromite is present in the serpentine at various localities, but the ore never seems to occur under such conditions as would repay working. Nor are the brown hæmatite-deposits at present of any industrial consequence, in view of the remoteness of the district in which they are situated.

An elaborate petrographical description is given of the various rocks mentioned, in the course of which a chemical analysis of the brown iron-ore is tabulated as follows:—Oxides of iron, 77·54 per cent.; silica, 1·63; alumina, 7·37; and water, 13·46 per cent. Only traces of phosphorus were found therein. The author believes that this ore is a deposit of lacustrine origin. In the Tawmaw serpentine there is a felspathic rock which simulates to a remarkable degree the white varieties of jadeite, and hand-specimens of it have often been collected in mistake for that mineral. The difference of specific gravities is a good macroscopic test, that of genuine jadeite being about 3·32, while that of the pseudo-jadeite does not exceed 2·6. Under the microscope, the last-named mineral is seen to consist of a highly cataclastic aggregate of felspars (most probably albite, despite an unusually high percentage of potassium). In this "felspathite" are long dark bands of graphite, which evidently represent the later infilling of cracks or fissures in the mass.

Jadeite belongs to the pyroxene-group; it is a heavy, extraordinarily hard and tough substance, generally exhibiting minute crystalline structure,

but more coarsely crystalline material is also found occasionally. It has a rough angular fracture, and sometimes it splits up in a platy fashion. Its average specific gravity is 3·32; hardness, 7; and its toughness, due to the web-like structure of its constituent granules, is such that it is almost impossible to smash it with a hammer. It is usually of a dazzling white, simulating a compact white marble; the highly-prized "noble" green jadeite occurs in much less quantity, in small patches, or in masses varying in size from a man's fist to a man's head, amid the white jadeite—into which it passes through an intermediate zone of paler green mineral. There are two well-recognized varieties of green jadeite: the brilliant emerald-green mineral, and the dull dark-green or bottle-green variety. One specimen, at least, examined by the author, had a soft pinkish-violet hue, not unlike that of amethyst. These differences in coloration are probably due to the presence of compounds of chromium, iron, and manganese in the respective varieties of the mineral. The modulus of elasticity in jadeite ranges between 3,000,000 and 47,000,000 (compare with the modulus in steel, ranging between 28,000,000 and 30,000,000). The ideally pure mineral is a metasilicate of soda and alumina, expressed by the chemical formula $Na\ Al\ (SiO_3)_2$, but it is practically never obtained in this theoretically pure condition. At Tawmaw, below the serpentine, and separated from it by about 20 inches of a soft chlorite-rock, comes a band of felspathite (albite-rock) with inclusions of hornblendite: this passes gradually into a mixture of albite and jadeite, and thence into jadeite alone, which forms the core of the "lode." Premising that the serpentine and the associated "crystalline schists" form a complex of contact-metamorphosed basic eruptive rocks, the author adduces in great detail the evidence which has led him to the conclusion that the jadeite was originally derived from a nephelinic magma through granitic contact-metamorphism at high pressure. The "crystalline schists" appear to belong to the category of metamorphosed gabbros, and the fact that soda-hornblende and chromite are among their constituents seems to point to some relationship between them and the jadeite-felspathite; the presence of chromium-compounds in the serpentine points in the same direction. The sequence of magmatic differentiations is pictured as follows: there was first of all an upflow of eruptive magma poor in silica and alkalis, which later split up, one portion attaching itself to the more central serpentine (originally peridotite), and the other to the marginal belt of crystalline schists (formerly gabbros). Then supervened the aplitic flow rich in soda, which perhaps originally consolidated into nepheline-aplite. This was metamorphosed, together with the other rocks of the series, by the later granitic eruptions, and thus gave rise to the jadeite-felspathite as we now see it. L. L. B.

RUBY-DEPOSITS OF NANYA-ZEIK, BURMA.

Beitrag zur Kenntniss der Rubinlagerstätte von Nanya-zeik. By J. J. Tanatar. *Zeitschrift für praktische Geologie*, 1907, *vol. xv., pages* 316-320, *with a map in the text.*

These deposits extend south-westwards from the village in the Kachin Hills, after which they are named, to Man-We, a region watered by the Indaw-Gee, flowing from south to north. On the left bank of that river, at Manwe, a granite seamed in all directions by veins of haplite and pegmatite crops out; and this, with marmorized limestones, continues all the way to Nanya-Zeik and beyond. In the neighbourhood of the last-mentioned locality, the junction between the granite and the marble is exposed; but it is not exposed

at the corundum- or ruby-placers north of Man-We, where a coarsely-granular marble is seen.

The author sets forth in detail the results of an examination of fourteen-hand specimens brought from the district, and of the microscope-slides made from each of them. From the right bank of the Indaw-Gee come antigorite-serpentine and felspathite (orthoclase-oligoclase rock), from the left bank injection-schists (gneisses), granite-haplite, and calc-sinter, also marbles containing in some cases graphite, in others serpentine and magnetic pyrites.

He then describes the sand from the corundum or ruby-placers of Man-we as consisting of grains and crystals of orthoclase (the predominant constituent), quartz, granite-haplite, phlogopite, chlorite, garnet, spinel, and ruby. Spinel is especially abundant in single, or frequently twinned and intergrown, crystals of various colours and dimensions: angles and edges are more or less rounded off, and the faces are more or less etched. In the material examined a granular ruby three-fifths of an inch in diameter was observed, as well as some smaller fragments. The latter are of a vivid red and transparent, while the bigger ruby is transparent only at the edges. The ruby-sands from Nanya-Zeik contain, besides ruby, orthoclase, phlogopite, chlorite, limonite, quartz, granite-haplite, and spinel. Orthoclase is here also the main constituent of the sand, and the limonite (evidently the decomposition-product of iron-ores) occurs in small nodules. In the material examined the rubies are found as small, vividly red granules: only once did the author find in it a ruby measuring as much as two-fifths of an inch in diameter.

The author agrees with Dr. F. Nœtling in holding that the marble rocks which are the original matrix of the Burmese rubies are Carboniferous limestones contact-metamorphosed by granitic intrusions. The clayey or aluminous impurities originally present in these limestones were, as a result of this metamorphism, crystallized into rubies. L. L. B.

GLAUBER'S SALT-DEPOSITS AND BRINE-SPRINGS IN THE YENISEI BASIN, SIBERIA.

Das Vorkommen von Glaubersalz (Mirabilit) und Solquellen am Jenissej-Flusse in Sibirien. *By* M. A. Nowomejsky. *Zeitschrift für praktische Geologie*, 1908, *vol. xvi., pages* 159-161, *with* 5 *figures in the text.*

The Varchy Lake, where solid deposits of Glauber's salts occur, and also common salt in solution, is barely 3 miles distant from the great navigable river, the Yenisei. It is situated in the Minussinsk district, between the town of that name and Krasnoyarsk on the Trans-Siberian Railway. The lakelet, of ellipsoidal form, its major axis being 1,280 yards long, and the minor 950 yards long, is really the north-eastern portion of a great syncline in the Devonian rocks, and the hills which hem it in on every side are built up of red and grey argillaceous limestones. In the months of drought, the lakelet dries up, and is covered with a thin pulverulent white crust of thenardite (anhydrous Glauber's salt); in the rainy months, this crust is dissolved, and the lakelet reaches its maximum depth of 20 inches! It is completely frozen over from the beginning of November until the end of March. The deposit of mirabilite (hydrated sodium-sulphate) was proved by boring in 1903 at a depth of about $7\frac{3}{4}$ feet below the bottom, and further careful investigations revealed the existence of a horizontal mass of crystallized mirabilite, $17\frac{1}{2}$ to 20 feet thick, covering nearly the entire area of the lakelet. This deposit has a roof of grey plastic clay, and a floor of pale-brown, occasionally white refractory clay. In the maximum thickness of 20 feet there are but

two small clay-partings (12 to 16 inches thick); and the total amount of mirabilite in sight is estimated at 2,750,000 metric tons or more. Chemical analysis shows the composition of the mineral to be remarkably constant throughout the deposit, the average percentages being: $Na_2 SO_4$, 40·10; $Ca SO_4$, 0·56; water of crystallization, 56·79; and mechanically mixed impurities (residues insoluble in water) 1·55. It is proposed to utilize the sulphate obtained from this deposit in the glass-works of Irkutsk and Tomsk.

In putting down a shaft for the purpose of working the deposit in February, 1907, the author struck, at a depth of 21½ feet, a pellucid brine-spring (16 degrees Baumé) which welled out of a fissure in the mirabilite near its base; the outflow was more conspicuous in summer, but the brine was throughout weaker. In January, 1908, the brine appeared to regain its original strength; and the daily flow was 660 gallons. The salt evaporated from this brine proved to be utilizable for culinary purposes, containing 94·04 per cent. of sodium-chloride. It is calculated that 8 metric tons of common salt can thus be obtained from this one spring every 24 hours. Further borings at several points in the lakelet have revealed other brine-springs of identical composition. The industrial importance of these finds is enhanced by the absence of a single soda-factory in all the vast territory that stretches from the Urals to the Pacific, and the consequently extortionate prices charged for soda in Siberia; and also by the possibility that the Varchy salt will, in Eastern Siberia, to some extent, displace the common salt now imported from European Russia at enormous expense. L. L. B.

RECENT SURVEYS IN THE GOLD-BEARING REGIONS OF SIBERIA.

(1) *Carte géologique de la Région Aurifère de l'Amour: Selemdja, Description de la Feuille II.* *By* A. Khlaponin. *Explorations géologiques dans les Régions Aurifères de la Sibérie*, 1907, *pages* 1-76, *with an index-map.*

The rocks of the district are crushed and mylonized gneisses, overlain by a series of metamorphic schists and slates; granites, aplites, diorites, hornblende-porphyrites; and finally post-Pliocene loams and recent alluvial deposits. Vein-quartz is not conspicuously developed. The auriferous alluvia within the limits of Sheet 2 of the Selemdja map are reckoned as the richest in the whole of the Amur region; and this abundance of gold seems to bear some close relation to the predominance of the mylonized gneisses, as also of mica-schists and quartz-hornblende-schists in the district there mapped. Added to which, the tectonic dislocations and the intensity of erosive agencies appear to have especially favoured the formation of placer-deposits.

(2) *Région Aurifère de l'Amour: Livraison VI.* *By* A. Khlaponin, P. Rippas, E. Ahnert, *and* M. Ivanov. *Op. supra cit.*, 1906, *pages* 1-104, *with* 4 *maps.*

The first-named author records the occurrence of outcrops of coal at five different points along the Bureia river, apparently associated with grits containing fossil plants which have been determined as Jurassic. Several analyses are tabulated, showing a range in percentage of carbon from 36 to 74. On the right bank of the same river, at the junction of mylonized granites and limestones, graphite and graphitic schists have been observed.

Mr. Rippas gives an account of the eastern portion of the Tukuringra range, an uninhabited mountainous area, in which no exploration-work, so far as gold is concerned, has yet been done. Mr. Ahnert describes traverses made through the basin of the Upper Zeia: here, the gold-placers of the Gargani, Sugdjari, and Kokhani rivers are situated along a belt of gneiss, the strike of which does not coincide with the trend of the mountain-ranges.

Mr. Ivanov describes the traverses which he made in 1903 in the basins of the Great Oldoï and Upper Gilui rivers. The gneissic belt along the middle and lower course of the Gilui, known already as markedly auriferous, is continued in the region of the Upper Gilui; there is every reason to believe that gold-placers will be found to occupy a large area therein. So far, however, there are only some small workings, conducted on very primitive lines (although started as recently as 1900) in the Ilich and Polgitli valleys: the gold-bearing deposit in the last-named valley is already well nigh exhausted. The distance from inhabited areas, the absence of practicable roads, the enormous cost of transport of stores, etc., and the extremely variable character of the alluvia in the gneissic belt, are all circumstances which forbid the hope of any rapid development of the mineral-industry.

(3) *Carte géologique de la Région Aurifère de la Léna: Description de la Feuille III.-6.* *By* A. Gerasimov. *Op. supra cit.*, 1907, *pages* 1-229, *with* 13 *figures in the text and* 3 *plates.*

Several pages of this memoir are taken up by a detailed description of the physiography of the area, which is typically rugged and mountainous. In the second chapter the geological formations are dealt with: they are roughly divisible into two main categories, (1) fluvio-glacial alluvia, older and recent, of enormous thickness, and (2) the metamorphic series, including carbonaceous phyllites, pyritiferous phyllites, calc-schists, spotted schists, gnarled schists, quartzites, etc., traversed by snow-white quartz-veins in which scarcely any gold appears to have been discovered so far. And yet, in the gold-bearing stratum in the placers, débris of rocks of the metamorphic series predominate; pyrites also, doubtless of similar derivation, abounds therein. The thickness of the gold-bearing stratum is extremely variable; moreover, gold is often found in the lower layers of the overlying barren deposits (or *torf*) and in the infilling (*primazka*) of the fissures in the disintegrated surface of the bed-rock. Often, the *primazka* is the richest portion of the placer, and contains a considerable quantity of visible gold. All the placers lying within the area described belong to the "valley-placer" type. The pyrites in the metamorphic rocks has been analysed, and shown to contain in one instance ·0204 per cent. of gold (or 6½ ounces per ton). It is probably the decomposition of the pyrites that has furnished by far the greater portion of the gold found in the placers. L. L. B.

COAL-MEASURES IN SOUTHERN ORAN, ALGERIA.

Sur le Terrain houiller du Sud-oranais. *By* H. Douvillé *and* R. Zeiller. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1908, *vol. cxlvi., pages* 732-737.

A brief history of the investigations which have been pursued by various explorers since 1900, when Carboniferous fossils were first recorded from the province of Oran, is given. This is supplemented by details of the following section on the road from Colomb-Bechar to Taghit, where the marine Carboniferous Limestone (Viséan) is succeeded by brown grits containing *Calamites*, *Lepidodendron*, etc., of Westphalian type, alternating with bands of fossiliferous limestone, and succeeded in turn by brackish and freshwater grits and shales with *Anthracomya*, and a rich Westphalian flora. These beds form part of a syncline, disappearing below detrital deposits for nearly 9 miles, and reappearing at Menuarar. It is the first time that a Westphalian flora has been found at so low a latitude. At Haci-Ratma, a very pulverulent and

much altered coal-seam has been discovered. It is only about $7\frac{1}{4}$ inches thick, and is, of course, unworkable; but this first discovery is a great encouragement to future prospectors.

At Haci-Ratma the shales and coal-plant-bearing grits are well nigh horizontal, and form a sort of bluff near the upper part of which is the seam just mentioned. The accompanying plant-remains are of Upper Westphalian type. A little farther west, at Gueltet-Ahmed, similar beds have been found with an almost identical flora, also *Spirorbis*, ostracoda, and *Anthracomya*; but at the base there is an intercalation of marine bands, and there is reason to believe that the section is lower down in the series here than at Haci-Ratma.

On the whole, the Carboniferous succession in the southern portion of Oran includes, above the Lower Dinantian, four distinct groups, being in ascending order:

Visean.	B.I.	Haci-Arlal beds (chiefly limestones) with *Productus giganteus*.
	B.II.	Menuarar limestones, with intercalations of sandy shale.
Moscovian-Westphalian.	C.I.	Cherassa beds, comprising *Lepidodendron*- and *Calamites*-grits, with some intercalated limestones.
	C.II.	Haci-Ratma sandy shales, with a rich flora and a brackish-water fauna.

The further search for coal must be, of course, chiefly directed to the uppermost beds (C), and the *Calamites*-grits will constitute a convenient stratigraphical indicator. The authors find considerable analogy between these Algerian Coal-measures and those of Britain; the list of fossil plants could be precisely paralleled in England or in the North of France, and it is suggested that Algeria in Carboniferous times formed part of the southern margin of a great transverse "mediterranean" sea, while the British area formed part of its northern margin. L.L.B.

PHOSPHATIC DEPOSITS OF ALGERIA AND TUNISIA.

Die Phosphatlagerstätten von Algier und Tunis. *By* O. Tietze. *Zeitschrift für praktische Geologie*, 1907, *vol. xv., pages* 229-251, *with* 10 *figures in the text.*

As in France itself, the phosphatic deposits of the French North African possessions occur either in the Cretaceous itself or near the junction between the Cretaceous and the Tertiary. The most important deposits, which have given rise to extremely active mining operations at Tebessa and Gafsa, occur in the very lowest Eocene, almost immediately overlying the Danian, or uppermost Chalk. A bibliographical list is given, embracing eighteen entries covering the period from 1888 to 1904.

It was in the department of Oran, at the seaport of Nemours, close to the Moroccan frontier, that phosphatic deposits were first discovered in Northern Africa. Here and elsewhere in that department the phosphates occur in pockets and as the infilling of fissures, and are evidently of late, possibly diluvial, origin; they are found chiefly in the Upper and Middle Miocene limestones (Sahelian and Helvetian). The phosphatic rock itself, with its black and brown banding, somewhat recalls agate; but it also occurs in the form of white and yellow concretions: it is generally very drusy and much fissured, the fissures being encrusted with crystals of aragonite. It is often also found in very nearly black granules, which have a tendency to stick together. The percentage of phosphate is extremely variable, as may be seen from the baker's dozen of analyses reprinted by the author. He concludes that these Oran deposits are precipitates from carbonated thermal waters.

In the department of Algiers occur various deposits which at present are

merely of local importance. Those found in the Lower Suessonian of Bogheri are, however, of considerable extent, and near Ain Sha it is calculated that at least 42,000,000 to 49,000,000 cubic feet of workable phosphate are in sight. In the department of Constantine, on the other hand, the phosphatic bands in the Suessonian are sufficiently rich to have given rise to mining operations on a large scale. Following an earlier writer, the author classifies these deposits topographically into four groups which he successively describes, namely (1) Bordsh Bu Arreridsh and Setif; (2) El Gerrah—Ain Beda; (3) Suk Arras and Guelma; and (4) Temessa. North-east of the last-named locality only one seam, about 10 feet thick, has been worked: the phosphate averages between 55 and 69 per cent., reaching a maximum of 73 per cent. in the richest portions.

The deposits in the Regency of Tunis may be topographically classified into three divisions: (1) those of the northern area; (2) those of the central area; and (3) those of the southern area. The older deposits, associated with calamine, are of comparatively small economic importance, although the mineralogical association is interesting. West of Gafsa in the southern district lies the deposit which yields more phosphate at the present moment than any other deposit on the surface of the globe. The section affords the customary Tunisian sequence: at the base, the blackish-brown gypsiferous and pyritiferous marls not exceeding 66 feet in thickness, followed by the phosphatiferous series, 260 to 300 feet thick, thinning gradually westwards; upon these follow several beds of compact limestones with remains of oysters and other lamellibranchs; and these again are overlain by gypsiferous beds, probably of Miocene age. The deposits of Metlaui and Radeyeff alone are computed to embody 17,000,000 tons of rich phosphate.

Considering the Algerian and Tunisian occurrences as a whole, the diminution in phosphatic content towards the northern and eastern coasts is regarded by the author as especially noticeable. He opines that this must have some connexion with the lie of the ancient Eocene coast-line. The phosphates are made up of a mass of rounded or angular granules, among which teeth of fishes, vertebræ, and cylindrical coprolites are easily recognizable; nodules of limestone are to be found, and among the finer constituents diatomaceous remains have been identified. The association of gypsum is noteworthy, and the origin of the phosphatic deposits is apparently identical with that of the similar well-known deposits in Northern France and Belgium. The Eocene phosphates occupy a thickness of 100 feet (at Gafsa 260 to 300 feet) between the dark marls, probably Cretaceous for the most part, and gasteropod-bearing limestones, overlain by Nummulitic limestones, of early Eocene age. The phosphatiferous beds consist of a series of phosphatic seams varying in thickness from an inch or two to 10 or 13 feet, alternating with more or less phosphatiferous marls and limestones containing flints. In coloration they vary from pale-grey to brown and dark-grey; in hardness they vary considerably. All give off a strong odour of petroleum when struck with the hammer. The last two pages of the paper are devoted to elaborate statistics of output and export. L. L. B.

A NEW SILICATE OF COPPER FROM THE FRENCH CONGO.

Sur une nouvelle Espèce minérale, provenant du Congo français. *By* A. Lacroix. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1908, *vol. cxlvi., pages* 722-725.

The only crystallized silicate of copper hitherto known in nature is dioptase ($Cu\ H_2\ Si\ O_4$), but in the Minduli copper-mine (French Congo) a

new mineral has been found, possessing crystalline structure and a constant or determinate composition. It occurs (1) in the form of dark-blue concretions with a mammillated surface and an extremely close-packed fibrous structure, mantling over rhombohedra of calcspar and bearing big crystals of dioptase on their surface; (2) of pale-blue spherulites, consisting of loosely-coherent needles, enveloped by malachite and native silver, and forming a growth on cuprite; and (3) of pale-blue asbestiform "fibres," barely 2 inches long, isolated in sandstone-fissures, and also occurring as small fibrous venules within the sandstone itself, much as chrysotile occurs in serpentine. The second of the above-mentioned forms of the new mineral constitutes the infilling of venules in a compact limestone, which is impregnated with chalcosite. The variations in colour and aspect are conditioned by the more or less perfect aggregation of the elementary fibres of the mineral: when dissociated mechanically into their constituent particles, and examined under the microscope, all three forms prove to be identical.

The specific gravity, on a somewhat low estimate, =3·36. Analyses of a selected specimen yielded the following results: silica, 37·16 per cent.; oxide of copper, 59·2; water, 4·5; and traces of iron. From this it would appear that the mineral belongs to a group intermediate between the ortho- and metasilicates, approximating to ganomalite. It may, perhaps, be considered as a basic metasilicate, corresponding to the chemical formula $(SiO_3)^{12}$ Cu^7 $(CuOH)^8$ H_2. The author names it plancheite, in honour of M. Planché, the donor of some of the best specimens of the new mineral.

That portion of the Minduli ore-deposit which has been so far explored consists of a compact argentiferous chalcosite, occurring in masses or impregnating a limestone which itself rests upon grits. Near the surface the chalcosite passes into malachite, occasionally by way of cuprite; and the silver separates out in the native state, in plates and in crystals among which the dominant form is the octahedron. Dioptase occurs still nearer the surface, in reniform aggregates dispersed among red clays, or in geodes within venules of calcspar which traverse the metalliferous limestone. L. L. B.

THE CUPRIFEROUS REGION OF KWILU-NIARI, FRENCH CONGO.

Notice géologique et minière sur le Bassin cuprifère du Kouilou-Niari (Congo français). *By* D. Levat. *Annales des Mines*, 1907, *series* 10, *vol. xi.*, *pages* 5-65 *and* 4 *plates.*

In the summer of 1906, the author made a prospecting tour (from the geological and mining point of view) through the Kwilu-Niari basin, following in a general way the old caravan-road which links up the harbour of Loango with Brazzaville on Stanley Pool: including the lateral deviations from the main route, purposely made in places, he roughly surveyed a series of geological sections over a distance of 400 miles or more. Complete security reigns in all the districts that he traversed, and the use of French coinage, instead of the old-fashioned barter in kind, has become all but universal.

Leaving the Atlantic sea-board at Loango, a belt of those Tertiary grits (some 25 to 40 miles in breadth), which border the entire western coast of the African continent in association with sand-dunes and vast deposits of laterite, is crossed; these rest directly upon the basement-granite, which appears to extend unbroken from the Congo river to the Kwilu-Niari. A broad stretch of Archæan rocks thrust up on end, and resting upon this granite, is covered by the famous Equatorial forest of Mayumbe. On reaching the upper valley of the Lubomo, a left-bank tributary of the Niari,

the pioneer comes upon great masses of supposedly Devonian limestone, not much folded, but simulating in a picturesque fashion a succession of ancient ruins. The limestone-tract of the Niari, taking account only of the visible outcrops, attains a breadth of about 125 miles in the latitude of Ludima, and it is very possibly the same limestones that re-appear on the other side of the great river-basin (the Congo) in Katanga, where the calcareous rocks and the associated metalliferous deposits have been of late the object of widespread public interest. Beyond Comba appear the red and white Triassic grits of Brazzaville and the Bateke plateau.

Describing first of all the Archæan belt of the Mayumbe forest (where he spent a fortnight), the author states that between Kakamoeka and Kitabi, a distance exceeding 12 miles, occurs a succession of massive, white, saccharoidal quartzites and highly-quartziferous lustrous schists, weathering grey or yellow, with which are interstratified numerous lenticles of quartz, varying in thickness from a few inches to several yards. This lenticular quartz is frequently charged with pyrite, to such an extent as to give rise to ferruginous gossans. All this formation is gold-bearing, as the author proved by repeated tests in the *batea*; but the local conditions are such as to make its workability extremely doubtful. Above Kitabi, not a trace of gold is to be found in the alluvia and sands of the streams which course through the district. On the whole, the Archæan rocks of this region may be classified as follows: (1) Kakamoeka schists and quartzites (auriferous); (2) Kitabi arkoses; (3) green schists, slates, and phyllites of the Bamba mountains; and (4) soft, marly Lubomo schists—none of the three last-named groups being auriferous.

The author traversed the Devonian basin of the Niari from west to east, from Ludima to Minduli, over its entire length, and also followed a zigzag course to its southern boundary at M'Boko Songo. The Devonian limestones rest unconformably on the soft, upturned Lubomo schists, but have so far failed to yield any characteristic fossils. Towards the base these limestones are extensively marmorized, their colour ranges from grey and blue to pink, and they can take a fine polish; above them come marly limestones and dolomites, with occasional unimportant intercalations of shale and marl; below them, such passage-beds as conglomerates and arkoses rest upon the older rocks. Above the calcareous series a brown or greenish coarse-grained grit occurs, which is an important factor in connexion with the cupriferous deposits; it is compact, hard, and extremely quartzose. It is not, however, of absolutely constant occurrence throughout the basin; and, occasionally becoming micaceous, it passes thence into thin shales, some of which are of a rich black and unmistakably bituminous. All the pre-Triassic strata above described have been subjected to the great north-westerly and south-easterly plication, the main axis of which is the Bamba range, a fold spreading fan-wise out to the Congo. The subsequent enormous erosion has, of course, more powerfully affected the areas of plication than those which were undisturbed by the ancient folding movements. The succession of the strata within the basin is extremely regular, and there seems to be no doubt that it continues both north of the Niari, and south of it across the Congo Free State frontier. In thickness this Devonian calcareous group certainly exceeds 1,300 feet. A detailed description of the limestones is given, and attention is drawn to a band of phosphatic nodules (some of which contain 42·5 per cent. of tricalcic phosphate), about 5 feet thick, which can be traced over quite a considerable area.

At a distance of 138 miles from Brazzaville by the Buenza route, and

211 miles from the harbour of Loango *via* Madingu, lie the ore-deposits of M'Boko Songo. They are below a great, apparently vertical fault, striking north-west and south-east, above which tower hill-summits, the lowest of which exceed an altitude of 1,800 feet above sea-level. The country hereabouts consists of undulating limestones conformably overlain by the yellow and brown Devonian grits, while farther south, towards the Free State border-line, the limestones are masked by the [? Triassic] red grits. To the south-west appear the high ridges of the reputedly gold-bearing Ochuma range, not very accessible under present conditions. Two metalliferous deposits worked by the natives occur on small bluffs, rising some 30 feet or so above the impenetrable cane-brakes through which meanders the Ludima river. The smaller of the two contains only a few traces of copper, but is essentially a plumbiferous and calamine-infilling of a fissure in the limestone. It does not appear to continue in depth, and exploration-work is being more usefully directed in its southward prolongation at the same horizon. The larger deposit is riddled with open-cast workings in a red ferruginous earth (evidently the decomposition-product of pyrite and chalcopyrite), in which latter occur concretions of malachite and azurite, easily smelted by the natives in small furnaces kept going by hand-bellows. A single hour's march from these deposits brings one to the Diengila or Vallat mine, which appears to have yielded ores much richer in copper than those of M'Boko Songo; besides oxides and sulphides of that metal, much calamine is found there, as well as cerussite and galena. Judging from the samples which he collected on the heapsteads, the author believes lead to be there the predominant metal. On the whole, the M'Boko Songo deposits are the results of the concentration at the surface of the limestones, or at shallow depths within them, of ores of copper, lead, and zinc, which were originally present in the conformably overlying grits. This view is confirmed by the discovery, in the Gandalonda ravines, of water-worn blocks of yellowish-brown and green grits containing various ores of copper as their original constituents, an occurrence which immediately suggests a comparison with the cupriferous grits of the Urals.

Like the M'Boko Songo deposits, those of Minduli have been actively worked by the natives from time immemorial. Here the Devonian limestones, massive, marmorized, dolomitic, are conformably overlain by a greenish, slightly cupriferous grit, enriched with ore near its base at certain points. At those localities where none of this greenish grit had subsisted for any length of time, no copper-ore occurs. Prospecting-work has been pursued over a distance of about 2 miles, and the first European prospectors were perhaps apt to build too much on the green and blue staining marking the outcrops, as these outcrops are by no means all of the same industrial importance. At some localities the limestone near the contact (with the grits) is completely silicified and traversed by a stockwork of thin venules of chalcosine. At the contact with the grits the joints in the limestone are richly mineralized with the ore, which contains geodes encrusted with dioptase, cuprite, and native silver—the last-named in quite notable proportion. Further, cupriferous deposits should be looked for where the folding of the rocks has been sufficient to initiate synclines, favouring the process of concentration of metalliferous ores at those points where the green grits overlie the limestones: the prospector need not, therefore, waste any time over the great plains of Ludima and Madingu, but should reserve methodic investigation for the head-waters of the Luvisi and the Lutete, and for the highly plicated area between M'Boko Songo and Minduli. A very small portion of the cupriferous basin of the Kwilu-Niari has been properly explored so far;

but, in any case, the great mass of the ores will have to be treated on the spot, and this implies the building of a railway to carry the necessarily imported fuel (coal and coke). Motive power, in the shape of waterfalls, is not wanting.

In describing the Bateke or Triassic grits, the author calls attention to their economic importance in quite another sphere than that of mining. When the forest is cleared of them, they are seen to bear in abundance a rubber-producing plant known as *Landolphia Thollonì*: it defies the annual bush-fires, on account of its underground "habit," very little of the plant appearing above ground.

The author discusses in detail the question of means of communication, and adduces all the evidence which tells in favour of the construction of a railway-line following the Ogwe valley, avoiding thereby direct, and probably unsuccessful, competition with the Congo Free State Railway.

L. L. B.

TSUMEB ORE-DEPOSITS, GERMAN SOUTH-WEST AFRICA.

Die Erzlagerstätte von Tsumeb im Otavi-Bezirk im Norden Deutsch-Südwestafrikas. *By* W. Maucher. *Zeitschrift für praktische Geologie*, 1908, *vol. xvi., pages* 24-32, *with* 3 *figures in the text.*

The locality in question is situated in the north of Hereroland, on the northern slope of the Otavi Hills, in 19° lat. S. and 18° long. E. of Greenwich, at an altitude of about 4,250 feet, some 42 miles north-north-east of Otavi. An account is given of the various expeditions which, under British and German auspices, established beyond question the industrial importance of the metalliferous deposits and surveyed the track of the railway (just completed) from the coast at Swakopmund (a distance of 350 miles or so). Mining operations have been in full swing since the end of the year 1905; underground workings were opened up by seven shafts, and there are also extensive open-cast workings. The poorer ores are smelted on the spot in two furnaces, and the lead- and copper-mattes thus obtained are exported to Europe as well as the richer ores, the monthly export averaging between 800 and 1,000 tons. Wood for timbering is available in sufficient quantity in the immediate neighbourhood; water for power-purposes is brought through conduits at high pressure from Lake Otyikoto, 12½ miles distant; and fuel (in the shape of coal and coke) is imported from Germany. The outcrop of the ore-deposit strikes east and west for a length of 183 yards; it has a breadth of 13 yards, and a height of 11 yards. The country-rock is a grey compact dolomite of Devonian age: at the contact between the upper part of the ore-deposit and the lower part fragments of sandstone and silicified dolomite make their appearance, and it is here that the metalliferous ores chiefly occur; while the lower part is of a dolomitic flaggy character. The upper part is of the nature of a sandstone, and rich masses of ore are of exceptional occurrence therein. A detailed description of the characters of all these rocks is given, as also of the ores. The latter are in part primary (sulphidic), in part secondary (direct oxidation-products of the primary minerals), and in part tertiary (formed by the chemical metamorphism of the secondary ores). In the eastern portion of the deposit highly plumbiferous minerals predominate, containing on an average 50 per cent. of lead, 10 of copper, ·5 to 2 of antimony, 1 to 2 of arsenic, ·02 of silver, and mere traces of gold. In the western portion, on the other hand, cupriferous ores predominate, with the following average composition:—15 to 25 per cent. of copper, 20 to 30 of lead, ·5 of antimony, 1 to 2 of arsenic, ·02 to ·03 of silver, and traces of gold. Between these two

portions intervenes a comparatively barren mass, consisting of the sandstone-like rock impregnated with oxidic ores, containing about 3 per cent. of copper and 4½ of lead. At greater depths, this barren mass wedges out, and the eastern and western portions of the deposit coalesce. The primary ores are chiefly galena, chalcocite (redruthite), arsenical famatinite, enargite, zinc-blende, and rarely pyrite. The direct decomposition or oxidation-products of these occur in the shape of anglesite, cerussite, linarite, caledonite, brochantite, etc.; and the "tertiary" ores comprise, besides the same minerals as the secondary, malachite, red copper-ore with nuclei of native copper, etc. Taking the western portion of the deposit as an example of the actual distribution of the ores, near the hanging-wall these occur chiefly in fissures among the sandstone-breccia, and linarite is their most characteristic and abundant representative; near the foot-wall, the deposit is characterized by the predominance of malachite and cerussite encrusting fresh or silicified dolomite; while in the central portion are masses of the primary or sulphidic ores encrusted with their decomposition-products.

It is supposed that, as the result of disturbance and over-thrusting in the Devonian strata, a line of weakness was developed between the dolomites and the sandstones, thus opening up a way for silicifying waters: into this fissure the author believes that the ores were injected at a later period in practically a molten condition. If this ore-deposit be indeed the outcome of magmatic differentiation, the less easily fusible ores (zinc-blende, pyrite, enargite, stibioluzonite) may be expected to predominate at greater depths; while the more easily fusible galena and chalcocite will correspondingly diminish.

In his concluding paragraph the author lays stress on the probable industrial value of the mottramite (a vanadinate of copper and of lead) which occurs in fairly large nests in the ore-body; vanadium is so high-priced and so much in demand, that any mineral containing it is worthy of consideration. The general absence of chlorine in the ores obviates any possible loss by sublimation in the course of smelting; and other reasons are adduced to show that, on the whole, the conditions, from the smelter's point of view, are extremely favourable. L. L. B.

PETROLEUM IN ANGOLA, PORTUGUESE WEST AFRICA.

A Riqueza Petrolifera d'Angola. *By* João Carlos da Costa. *Sociedade de Geographia de Lisboa* [*separate publication*], 1908, *pages* 1-15.

The province of Angola, covering an area of 486,372 square miles, is one of the most extensive of Portugal's oversea possessions, and traces of petroleum have been observed along a belt of country trending from north-west to south-east for some 600 miles, from Cabinda to Porto Alexandre. There is reason to believe that the petroliferous belt extends beyond these two localities, more especially beyond the northernmost, into British Guinea, where on the Gold Coast, near Axim, oil- and bitumen-bearing strata, similar in character to those which crop out in the Portuguese colony, are known to occur.

The chief localities for petroleum cited by the author and visited by him in Angola, proceeding from the north, are (1) Sampla, a native village, 36 miles north-east of the small coast-town of Quinzáu, where the Mazamandombe (or "Blackwater River") is discoloured by infiltrations of petroleum welling up from its bed; (2) N'Gondo, 18½ miles east of Quinzáu, where a natural well, from which issue very heavy petroleum, gases, and water, occurs on a small eminence; (3) Musserra, on the sea-coast, where the strata seem to

be saturated with petroleum, and rounded masses of bitumen are found on the beach, while the very sea-waves are filmed with oil; (4) Dande, locally famous since many generations for its mountain of bitumen (Matadi-Ma'husso), almost entirely built up of natural asphalt, and yielding undoubted indications of the presence of petroleum. In the course of his prospecting-work there, the very first boring which the author put down struck (close to the surface) a well of natural gas, of high illuminating power. Whereupon the native "boys" who were working under him took to flight, as they thought that he was a maleficent wizard. The neighbourhood is of easy access, and the magnificent harbour of Loanda is only 37 miles distant; (5) Undui, a few miles to the north-west of the bitumen-mountain, where there is evidence of petroleum in small quantity; (6) similar indications occur 3 miles from Caxito; (7) Old Benguella or Benguella-Velha, a few miles south of Loanda, concerning which nothing definite can be said until extensive boring-operations have yielded sufficient data. On the left bank of the Quanza, at Cambullo, there is a tiny vein of bitumen, apparently of small industrial value, which has from time to time given rise to the most extravagant statements regarding supposititious coal-deposits in that district.

The author believes that a brilliant future awaits the petroleum-industry of Angola, which is shortly to be started on a grand scale.

L. L. B.

SALAGASTA COAL, ARGENTINE REPUBLIC.

Nota sobre el Carbón de Salagasta. *By* E. Herrero Ducloux. *Anales de la Sociedad Científica Argentina*, 1907, *vol. lxiii., pages* 165-168.

Since 1895 the number of known coal-deposits within Argentine territory has been much increased, and there is now no question as to the industrial value of the mineral yielded by the coal-bearing strata of San Julián (Santa Cruz), Las Higueras and San Rafael (Mendoza), Tilhué and Curileuvú (Neuquen). The most recent samples obtained from Las Higueras have yielded the following analysis (a great improvement on the results obtained from the same locality in 1904):—fixed carbon, 50·067 per cent.; sulphur, 1·204; volatile matter, 30·735; ash (pale yellow), 9·848; hygroscopic water (expelled at 105° Centigrade), 9·35; heating-power, approximately 5,800 calories. The mineral is of a lustrous black, with a greyish-black streak; its specific gravity is about 1·4; it yields 60 per cent. of coke. From the Blue Mines of Jujuy, in the department of Javé, comes a black coal, of only 1·2 specific gravity, which contains a little over 41 per cent. of fixed carbon; 53·25 of volatile matter; 3·5 of hygroscopic water; and yields about 2·1 per cent. of ash, and 43·26 per cent. of coke. Its heating power is approximately equivalent to 6,000 calories.

Of far greater importance, however, are the recently-discovered deposits of Salagasta, north-west of Mendoza city; they have been described in great detail by Señor Luis A. Huergo in the *Revista de Geología y Minas* for 1906. The author submits the results of the recent analyses of the "coal" made by him, as follows:—

Specific gravity	1·533	1·605.	
Humidity at 105° Centigrade ...	8·684	8·625	per cent.
Ash (pale to pinkish-yellow) ...	24·455	36·472	do.
Coke	63·980	68·360	do.
Fixed Carbon	39·525	32·158	do.
Volatile matter	27·336	22·745	do.
Heating-power	4,805	3,527	calories.

He also supplies detailed analyses of the ash, showing that it consists mainly of silica and alumina, with but little sulphur, phosphorus, and iron.

Presumably the mineral should be termed rather a lignite than a coal; it yields a greyish-black streak, occurs in great abundance, and its quality appears to improve concurrently with the increase in depth from the surface. The local conditions of transport are favourable; moreover, there is a great demand in the neighbourhood for fuel, as firewood is scarce and dear. There are copper-mines in the vicinity, which are lying idle for want of fuel.

L. L. B.

ZINC-BLENDE DEPOSIT IN OURO PRETO, BRAZIL.

Nota sobre uma Jazida de Blenda, no Municipio de Ouro Preto. *By* Joaquim Candido da Costa Sena. *Annaes da Escola de Minas de Ouro Preto*, 1906, *No.* 8, *pages* 17-22.

This deposit occurs at a locality known as Morro do Bule, 3¾ miles distant from the Henrique-Hargreaves railway-station, on the Ouro Preto branch-line, in the limestones overlying the quartzites of the Serra de Ouro Branco. The rocks strike from north-west to south-east, and dip 45° to 50° eastward. The blende is found infilling fissures in the limestones, and was probably precipitated therein from waters carrying metallic sulphides dissolved in an excess of alkaline salts; it forms a main lode, which at some points attains a maximum thickness of 12 inches, and also ramifies in the narrower fissures into stringers which do not exceed a fraction of an inch in thickness. On the surface of these latter the author found crystals of calamine exhibiting radiate structure. At some parts of the deposit, the adherence of the blende to the limestone is so feeble, that, by using wooden wedges, the author was able, with very little trouble, to break away samples of ore weighing as much as 176 pounds. On the walls of the fissures cubes and octahedra of crystallized pyrite are abundant, and in some cases they encrust samples of the blende. Quartz is of comparatively rare occurrence here, but a yellow amorphous mineral, occasionally pulverulent, occurs in abundance: it proves, on analysis, to be an antimoniate of lead (bindheimite).

The blende itself is almost black, with a yellowish tinge, and is found in granular masses. Its specific gravity lies between 3·8 and 4, its hardness is 4, its lustre occasionally resinous; and a selected sample was shown on analysis to contain 62·16 per cent. of zinc, 3·84 of iron, 32·08 of sulphur, 0·52 of arsenic, 0·09 of antimony, traces of lead, 0·58 of lime, and 0·61 of insoluble residue (silica). Another sample yielded 2·4 per cent. of cadmium. Assays of four samples, made in the School of Mines of Ouro Preto, yielded on an average 3·89 ounces of silver and 31 grains of gold per ton of ore.

No statement is made in regard to the industrial importance, or otherwise, of the deposit.

L. L. B.

THE SEARCH FOR COAL IN SOUTHERN BRAZIL.

Pesquizas de Carvão no Sul do Brazil. *By* B. J. dos Santos. *Annaes da Escola de Minas de Ouro Preto*, 1907, *No.* 9, *pages* 65-87.

The coal-bearing formation of Brazil extends from the south of the State of São Paulo to the Rio Grande do Sul, the beds increasing in thickness as they stretch away southwards; thus, the coal-bed known as the "Barro Branco" or "White Band," 12 to 20 inches thick in the State of Paraná, thickens to 3¼ and 4¼ feet in Santa Catharina, and to 7½ or 8 feet and even more in the State of Rio Grande do Sul. The coal-seams dip generally south-

wards, those which crop out in the State of Paraná, about 2,900 feet above sea-level, being identified farther south at altitudes diminishing respectively to 750, 300, and 150 feet, and being actually proved by exploration-work in the Arroio dos Ratos at over 300 feet below sea-level. The coal-measures are chiefly made up of grits (with predominantly calcareous cement), clayey shales, and clays. Black shales generally alternate with the coal-seams, and conglomerates occur at lower levels. Four great coal-horizons have been recognized and the two lowermost, the Bonito and the Barro Branco, have been completely explored in Santa Catharina. The Bonito seam reaches at some localities an enormous thickness, exceeding, for instance, 16½ feet in the Tubarão Mines; unfortunately, the coal is always much intermingled with black shale. The floor and roof are formed by a clayey-black shale, penetrable with great difficulty by the diamond boring-tool. There are, however, seams of pure coal, 3¼ feet and more in thickness. The Barro Branco is regarded as the best seam, both from the point of view of its continuity, and from that of the quantity and quality of the coal which it yields. It is split up into two, often into three, by partings of the characteristic pale-yellow grit, to which the seam is said to owe its name. Above the Barro Branco comes the Caraháseam, with a thickness of about 20 inches of pure coal; the fourth or uppermost seam is of no considerable thickness.

The Bonito and Barro-Branco seams do not appear to be represented at all satisfactorily in the State of Paraná. A section is cited on the Cedro homestead, where about 1 foot of very lustrous coal underlies the yellow grit; other sections in that State are described showing still thinner seams. About 35 miles north-east of Tibagy, however, is perhaps the best exposure, showing three seams respectively 19 inches, 8 inches, and 10 inches thick. The possibility of workable petroleum-reservoirs being struck at considerable depths both in the State of Paraná and in that of São Paulo is discussed.

In the State of Rio Grande do Sul, the Barro-Branco seam is being worked in the Arroio dos Ratos mine, on the banks of the Rio Jacuhy, an hour's journey from the railway-line; there is a winding-shaft and also a ventilation-shaft going down to a depth of 330 feet. The workings are spacious, and the roof is so firm in places that but little timbering is necessary. The upper portion of the seam consists here of about 5 feet of pure coal, the middle portion of 32 inches of coal and shale (the latter predominating), and the lower portion of 4½ feet of pure coal; occasionally the middle portion pinches out altogether, and there are points where the total thickness of the seam reaches 16½ feet.

The coal-measures are well represented in the State of Santa Catharina, and the finest outcrops known occur at the Tubarão mines, at the terminal point of the 50-mile railway which runs from the harbour of A Laguna, across a country almost entirely made up of granite. Sedimentary rocks make their first appearance barely a mile and a quarter away from the mines. The author describes the boring which, after encountering great difficulties, he completed in that neighbourhood in January, 1905; it showed that no coal-seam is in existence below the Bonito seam, which is separated from the underlying granite by only 250 feet of stratified deposits. He describes two other borings successfully completed in 1906, in one of which a seam of coal 12¼ feet thick was struck (not including shaly partings), and in another at Treviso, 13 or 14 miles away to the south, a seam containing no less than 33 feet of coal, separated by about 4 feet of carbonaceous shale, was struck. The stratigraphy in the last-named locality is complicated by the dykes of intrusive diabase, occasionally of enormous thickness, which traverse the rocks

in various directions. At Cresciuma (barely 145 feet above sea-level) the most favourable exposure shows four seams, the thickest of which hardly exceeds 13 inches; the coal is very lustrous and pure, containing but little iron-pyrites.

It is stated that the Cedro coal (Paraná) in heating capacity bears to Newcastle coal the relation of 96:100; in coke-yield that of 92:100; and in ash 100:95. A sample, analysed at the Ouro Preto School of Mines in 1906, yielded 51·8 per cent. of fixed carbon; 32 of volatile matter; 7·7 of water; and 8·5 of ash; the heating-power was determined as equivalent to 5,400 calories. L.L.B.

COAL-OUTCROPS IN THE PARANÁ REGION, BRAZIL.

Sobre alguns Affloramentos de Carvão no Paraná. *By* E. P. DE OLIVEIRA. *Annaes da Escola de Minas de Ouro Preto*, 1907, *No.* 9, *pages* 91-94.

All the outcrops visited by the author occur in a small group near the boundary between the Carboniferous and the Devonian formations, the easternmost being those of Teixeira Soares. About 3 miles north-west of that locality, a seam of coal and pyrite not much more than an inch thick is intercalated among black shales underlain by white grit. A mile and a half still farther north-west, a yet thinner seam is found, overlain by yellow grit, and underlain by black clay (about 8 inches thick) full of fragments of coal and fossil plants; below this again comes about a foot of shaly clay containing nodules of pyrites. At another point the last-mentioned bed is especially rich in magnificently-preserved impressions of *Calamites* and other fossil-plants.

Little venules of coal occur amidst plant-bearing black shales near Imbituva; about 9 miles north of that locality, at O Cedro, a seam of pyritous coal, rather more than 3 inches thick, underlies yellow grit, and is itself underlain by about 10 inches of black carbonaceous shale. Somewhat more than 5½ miles to the north-west, a seam of coal with a little shale, about 8 inches thick, crops out in the bank of a stream which runs into the Arroio Grande. About 5 miles south-west of Teixeira Soares, and 115 feet lower down in the series than the outcrops already cited, the author found a seam of coal with shale and pyrites 10 inches thick.

But one of the most characteristic geological horizons in the Carboniferous formation of this region is that of the black bituminous shales containing fossil Reptilia. These have long been known at Iraty—leaving that locality, however, aside, the author describes the occurrence in the neighbourhood of Canoinhas. Going north-eastwards from that town, the traveller crosses successively shaly clays of various colours overlying the black shales; but the luxuriance of the vegetation allows of scarcely any extensive exposures. The sedimentary formations are traversed by a few dykes of diabase; and this igneous rock accompanies the hard layers of black shale, smelling strongly of kerosene, which forms much of the bed of the Tigre, an affluent of the Rio Negro, 8 or 9 miles away from Canoinhas. A sample of the shale, distilled in the laboratory of the Ouro Preto School of Mines, yielded 10 per cent. of light oils (containing essence of petroleum) and 20 per cent. of heavy oils, consisting almost exclusively of petroleum; also a solid substance presenting the appearance of paraffin. This analysis, however, is far from representing accurately the actual wealth of these shales in petroleum and its derivatives.

The same shales, again with reptilian remains and nodules of chert, form much of the bed of the Pardos, a tributary of the Rio Canoinhas, 7½ miles south-west of the Tigre. L. L. B.

COBQUECURA BROWN-COAL-DEPOSIT, CHILE.

Los Yacimientos carboníferos de Cobquecura, Departamento de Itata. By Julio Schneider. *Boletin de la Sociedad Nacional de Minería*, 1907, *series* 3, *vol. xix.*, *pages* 409-412.

The Cobquecura deposit (belonging to the same lignitiferous formation as that which farther south is regularly developed along the Chilian coast, and embraces the mines of Coronel, Lota, Lebu, etc.) rests upon, and is surrounded on all sides by, the Archæan crystalline schists. It is situated at an altitude of 500 feet or so above sea-level, and its seams dip only 4 or 5 degrees southwards and south-eastwards. The surface of the district is but slightly undulating. Exploration-work has revealed the following succession in descending order:—

	Thickness in Feet.	Thickness in Inches.	
1. Brown-coal seam	0	4	In the next neighbouring ravine, the crystalline schists underlying the deposit are seen to a vertical depth of 10 feet.
2. Shaly clay	3	3	
3. Brown-coal seam	0	5 to 8	
4. Shaly, in part carbonaceous clay	1	6	
5. Brown-coal seam	0	5 to 7	
6. Shaly, in part carbonaceous clay, with a venule of coal barely an inch thick.			

Work has been started on the second and third of the seams just enumerated: westwards they do not appear to thicken, but southwards the upper seam (3) has a thickness of 20 inches and the lower (5) a thickness of 10 inches. The mineral is of very uniform composition, and analyses of two samples have yielded the following percentage results:—

Fixed carbon	43·0	46·8
Volatile matter	35·2	30·7
Water	7·8	6·5
Ash	14·0	16·0
Heating power in calories	5,000	4,730

Unfortunately, the coal contains also as much as 3½ per cent. of sulphur, which affects considerably its industrial value. About a mile north-west of the workings just described, and at an altitude of 450 feet above sea-level, two outcrops occur of a very pure brown-coal, in seams 8 inches thick, separated by a vertical distance (of barren rock) of barely 3¼ feet. A small digging, made at the author's suggestion, some 75 yards to the south of the first workings, yielded a coal containing 43·6 per cent. of fixed carbon; 41 of volatile matter; 8·5 of water; 6·9 of ash; and possessing a heating-power of 5,850 to 6,000 calories.

The white and pale-yellow sandstones associated with the brown-coal deposits are described, and it is assumed that there is no doubt of their Tertiary age. They form a shallow basin, covering about 1,000 acres, the longest diameter of which ranges north and south.

THE LIGNITE- OR BROWN-COAL-DEPOSITS OF CHILE, SOUTH AMERICA.

Distribucion jeológica i jeográfica del Carbon en Chile. By Miguel R. Machado. *Boletin de la Sociedad Nacional de Minería*, 1907, *series* 3, *vol. xix.*, *pages* 330-337.

The author begins with stating that since 1905 no fresh discoveries of importance have been made, in regard to the possible extension of the coal-

bearing belt of Chile. All the coal hitherto worked in that country is to be ranged in the category of lignite or brown-coal. The deposits are briefly described in the following geographical order:—

Santa Maria belt.—In this area, bounded on the north by the Bio Bio River, on the south by Contulmo, and on the east by the Nahuelbuta range, occurs the best coal to be got in Chile. It is greyish-black to lustrous black, compact, and tends to run in seams; its specific gravity varies between 1 and 1·25; it burns freely with a long bright flame, yielding much black evil-smelling smoke, and a good deal (2 to 11 per cent.) of white to yellowish ash. Its maximum heating-power is equivalent to 6,500 calories; it contains from 48 to 53 per cent. of fixed carbon, 28 to 43 of volatile matter, and 3·5 to 5·5 of hygroscopic water. The principal concessions, going from north to south, are those of Puchoco, Playa Negra, Lota, etc. A short distance south of Lota the Tertiary deposits give place to the Archæan crystalline schists, which continue as far as the Rio Carampangue, where the Tertiaries begin to reappear. South of that river are the Colico mines, yielding coal as good as that of Lota or Coronel; a little farther south again, the Curamilahue mines have yielded a mineral of excellent heating power, but the difficulties of working are now enhanced by the excessive faulting of the seams to great depths. Other coal-outcrops are known hereabouts, but have not yet been thoroughly explored. Round about Lebu mines are being worked, and coal crops out at many places along both banks of the river of the same name. There is a characteristic plant-impression (?) known as *Holothurites quiriquinal*, which is a good indicator of the occurrence of workable coal, as it is found in the uppermost layers of the beds underlying the best lignite-seams. Of course, if these seams have been denuded away, it is of no use to look for the lignite *below* the strata containing the above-mentioned fossil: the melancholy story of the abandoned enterprise of Huenapiden, where a boring actually 1,500 feet deep was put down in the vain search for non-existent coal, illustrates this remark.

Quiriquina belt.—The coal-measures here occur north of the Bio Bio; and the most important mines, in regard both to quality and to quantity of output, are those of Cerro Verde, near Penco, but they are in no wise comparable with the mines of the Santa Maria belt. The typical Quiriquina coal is of a lustrous greyish-black on fresh fracture; it contains from 25 to 47 per cent. of fixed carbon; 35 to 49 of volatile matter; 12 to 15 of hygroscopic water; yields 2 to 12 per cent. of ash; and its maximum heating-power is equivalent to 5,700 calories. The very perfect lignite of Cobquecura yielded on analysis: 4·7 per cent. of water, 38·9 of volatile matter, 38·9 of fixed carbon, and 17·5 of ash. Its heating power is equivalent to nearly 6,000 calories, but it does not appear to occur in sufficient quantity to justify working on a commercial basis.

Valdivia belt.—Since 1905 the fame of the coal-outcrops has become more widespread. They occur on both flanks of the Nahuelbuta range, at some little distance from the Pacific seaboard. The coal occurs in lenticular deposits, is generally compact, of a greyish-black, with somewhat of the lustre and character of jet. It has a conchoidal fracture, burns with but little flame, and in burning gives off a pungent odour. It contains from 25 to 36 per cent. of fixed carbon, 31 to 37 of volatile matter, 14 to 20 of hygroscopic water; yields 3 to 24 per cent. of ash; and its heating power ranges between 3,000 and 4,500 calories. The principal outcrops known are enumerated (about fifteen localities): in the Nielol area of the province of Cautin, borings were put down in 1904, and the Rapa coal-seams were struck after going

through about 90 feet of rather hard clay, etc. Some distance north of Rapa the Huimpil deposits have been re-explored within the last two years. The coal which they yield, both in its aspect and in its manner of burning, recalls anthracite. It has a semi-metallic lustre, crumbles away in the fire, and needs a very strong draught to set it alight. The author believes it to be a Tertiary lignite, contact-metamorphosed by eruptive rocks. In the island of Huato, south of Chiloé, a greyish-black lignite has been found with conchoidal fracture, and showing much external resemblance to the Nielol coal. It contains 46·7 per cent. of fixed carbon; 29·8 of volatile matter; 16·8 of hygroscopic water; yields 6·7 per cent. of ash; and its heating-power is equivalent to 4,800 calories. The great seam of Loreto, near Punta Arenas, yields a compact greyish-black lignite, showing conchoidal fracture, and crumbling away after having been for some little time exposed to the air: hence its utility for industrial purposes is much diminished.

Cordillera of the Andes.—The coal of this belt presents all the mineralogical characters of anthracite. It is of a deep black, with a semi-metallic lustre and conchoidal fracture. Its heating power ranges from 5,100 to 7,500 calories. The strata in which it occurs are either of very late Palæozoic or very early Mesozoic age. A description is given of the deposits 650 feet above the Ternera ravine, in the Cerro de Paipote, 12½ miles from Púquios, and 6,135 feet above sea-level. Here are fourteen seams, striking from south-south-east to north-north-west, and respectively varying in thickness from 4 to 6 feet. The author has made an analysis of a specimen of the coal obtained in 1907, with the following results:—Fixed carbon, 59·3 per cent.; volatile matter, 7·5; hygroscopic water, 5·5; ash, 27·7. The heating power is comparatively low (5,100 calories), but this is doubtless due to the excessive quantity of ash which the coal yields.

Noting that nearly all the Tertiary coal-deposits of Chile occur at no great distance from the sea, and that the seams generally dip westwards, the author holds that the vegetable material which gave rise to them came from a continent now buried beneath the waters of the Pacific. L. L. B.

THE BELLA UNION QUICKSILVER-MINES, MEXICO.

Description des Mines "La Bella Union" (État de Guerrero): Génèse des Gisements de Mercure. By Juan D. Villarello. *Memorias y Revista de la Sociedad Cientifica "Antonio Alzate,"* 1906, *vol. xxiii., pages* 395-411.

The mineral-field known as La Bella Union consists of thirty-six claims occupying an area of about 92 acres, some 2 miles south of the village of Huitzuco, district of Hidalgo, in the State of Guerrero. It is 17½ miles distant by cart-road from the railway-station of Iguala. Barely a mile and a quarter north of La Bella Union are the long-established quicksilver-mines of the La Cruz y Anexas company.

The rocks of the district are predominantly the massive Middle Cretaceous limestones which extend from Cachuamilpa, by the north-east of Tetipac and Tehuilotepec towards Iguala and Huitzuco; they are cut off on the west by the andesites of Noxtepec and Taxco. Fissures in the rocks are of frequent occurrence, many of them communicating with cavernous hollows dissolved out of the limestone, in some cases by the action of surface-waters, in others by the action of thermo-mineral waters gradually enlarging the fissures through which they percolated. The metalliferous deposits of La Bella Union consist of the infilling of these fissures, the ores of primary differentiation being cinnabar and iron-pyrites, with small quantities of metacinnabarite

and native mercury, in a calcitic and gypseous gangue; while among the ores of secondary differentiation are oxides of iron, with which small crystals of cinnabar are commingled. Cinnabar also occurs in the calcite, to which it communicates a pink tinge. Exploration-work has not yet been pursued to a sufficient depth in the Bella Union field to permit of a reliable estimate of the actual dimensions of the deposits, but there is no reason to suppose that they will prove to be of less importance than the neighbouring and geologically identical deposits worked by the La Cruz y Anexas syndicate. It is noted by the way that the distribution of the rich ore is extremely irregular both in direction and in depth, and the endeavour to restrict mining operations to the best mineralized belts has not been very successful: most of the ore extracted contains but little mercury, and rich ore has only been worked over small areas. The metalliferous infilling of the cavities in the limestone does not appear to be the result of metasomatic substitution as between that rock and the thermal mineral waters which percolated through the fissures thereof: it would seem rather as if the ores had been deposited in pre-existing cavities. It may be observed that the cinnabar is more frequently met with in the narrow fissures than in the wider cavities of the limestone: these latter are mostly filled with a ferruginous clay seamed with venules of cinnabar. The sulphantimonite of mercury (livingstonite), found abundantly in the La Cruz mines, will probably be met with at the Bella Union when exploration-work has reached the horizon of the primary sulphides or the ores of primary differentiation. The limestones are neither silicified nor marmorized. The ore-deposits are probably of Tertiary age, and there is doubtless a genetic relationship between them and the above-mentioned Tertiary andesites of Noxtepec and Taxco.

Commenting on the great similarity in character of quicksilver-deposits as a whole; on the constant association of particular minerals therewith; and on their genetic relationship with sulphuretted thermal waters, the author holds that a common mode of formation may well be assigned to such deposits. Now, cinnabar is easily soluble in thermal waters which are at a high temperature, and its deposition appears to have taken place from comparatively cool sulphuretted thermal waters arising from sulphydric fumaroles, in the latest phase of the consolidation of an igneous magma. It is true that quicksilver-deposits may be formed from high-temperature sulphuretted thermal waters; but, in that case, the precipitated cinnabar must in some way be protected from subsequent percolation of sulphur-charged waters—as happens, for instance, when cinnabar is deposited in the pores of a rock, rendering the previously porous and permeable mass impermeable to the circulation of fluids. Where the cinnabar is not protected from such percolation it tends to migrate towards the surface, *pari passu* with the diminution in temperature and in metalliferous contents of the aforesaid thermal waters: the migrated cinnabar envelops the sulphides contemporaneous with its primary deposition, and these (such as the sulphides of silver and lead) are indestructible under the new conditions, because they are insoluble in comparatively cool sulphydric waters. The conclusion is arrived at, that it is generally the superficial portion of quicksilver-deposits which is of greatest industrial importance; also that migration of cinnabar being easiest in narrow fissures, in depths these will be better mineralized than larger cavities. Further, that areas of enrichment may be looked for at the intersection of the deposits with transverse joints through which oxidizing surface-waters have percolated. The chemical and mineralogical composition

of the country-rock has no effect, one way or the other, on the mineralization of quicksilver-deposits; but the porosity and the permeability of the rock are all-important. The ore from the San Simon and San Esteban mines in the Bella Union field contains about 2·10 per cent. of mercury; but, on an average, that extracted from the other mines there only contains from 0·2 to 0·5 per cent. A two-furnace smelter erected on the spot has failed to yield satisfactory results, about 40 per cent. of the mercury being lost in the process of smelting. L. L. B.

COBALT IN THE STATE OF JALISCO, MEXICO.

El Cobalto en el Estado de Jalisco. *By* D. V. Navarro. *Memorias de la Sociedad Científica "Antonio Alzate,"* 1907, *vol. xxv., pages* 51-57.

The smaltite of the Esmeralda mine near Pihuamo was first discovered a quarter of a century ago; but the remoteness of the locality and the difficulties of communication buried this discovery in oblivion, until the matter was taken up energetically within the last few years, and a company was formed to work the mineral. The mine is situated at an altitude of 3,825 feet above sea-level, some 4½ miles east of Pihuamo, and about 11 miles distant from the nearest station on the railway now under construction between Tuxpan and Colima. As the mine lies on the western slope of the very rugged Sierra del Alo, the track from it to the foot of the Sierra is hardly suitable for wheeled traffic; but from that point to the Central Railway cartage offers no difficulties. The Esmeralda mine has opened up a thick lode of magnetite, striking 37 degrees north-westwards and dipping 80 degrees north-eastwards, below which a lenticle rich in cobalt-minerals has been worked. This lenticle averaged 1 foot in thickness, and contained chiefly massive smaltite (occasionally exhibiting octahedral crystals) with smaller quantities of cobaltite, and splotches of erythrite and arsenate of nickel. In places, asbolite and minute quantities of native bismuth were found. The gangue-minerals were calcite, dolomite, and very rarely quartz. The extracted ore, yielding on assay 10 to 20 per cent. of cobalt; ·8 to 1 of nickel; 7 to 15 of arsenic; and 1 to 2 of sulphur, was exported to Germany.

The magnetite-lode, abundantly impregnated with pyrites, like many others in the neighbourhood, crops out over a length of several hundred yards, and preserves a certain regularity, both in strike and in dip. In its lower portion a band of calcite intervenes between it and the country-rock, and points to a probable re-opening of the original fissure at a period subsequent to the ferruginous infilling. The numerous magnetite and hæmatite-lodes of the Sierra del Alo have been vainly explored, in the hope of finding other cobaltiferous deposits associated with them; but ores of copper and lead have been found in sufficient quantity to repay working.

The geology of the area is sufficiently simple: the rocks consisting mainly of Cretaceous limestones and clays, dislocated and folded, were intruded into and overwhelmed by Tertiary eruptives. The metalliferous lodes occur in wide and numerous fissures yielding ores of high grade; they are easily worked; the climatic conditions are favourable; in fact, all the circumstances are such as to justify the enhanced activity in mining operations which the author predicts in the near future for the Pihuamo district of the State of Jalisco.

L. L. B.

BORAX-DEPOSITS OF SALINAS, PERU.

Informe relativo à las Pertenencias ubicadas sobre el Yacimiento de Borax de la Laguna de Salinas. By Alberto Jochamowitz. *Boletin del Cuerpo de Ingenieros de Minas del Perú*, 1907, *No.* 49, 30 *pages, with* 1 *plate and* 2 *maps.*

The first concessions for working these deposits were granted in May, 1893, others were granted in 1899; and then it was found that there was, probably owing to cadastral errors, overlapping of concessions, with the result that the Peruvian Government was petitioned to resurvey the whole area, concession by concession. A detailed account is given of the procedure adopted, as also a list of the unoccupied areas—which have been accidentally left between the original concessions, and all contain borax-deposits.

The Salinas "lagoon" lies on the boundary of the departments of Arequipa and Moquega, east of the departmental capital of Arequipa, from which it is distant 12 leagues by pack-road—say, two short days' journey, there being a rise of 6,600 feet from Arequipa to Salinas (which lie over 14,000 feet above the sea-level); and moreover a pass at an altitude of 16,000 feet has to be negotiated before the traveller descends to the borders of the lagoon. This lies in the bottom of a great depression ringed round by high mountain-ridges of volcanic origin. The highest and westernmost peak, the Pichu-Pichu, appears to represent the ancient terminal point of eruption of a great fissure, more than 25 miles long and perfectly straight, the course of which is demarcated successively by the volcanoes of Coropuma, Chacham, Misti, and the above-mentioned Pichu-Pichu: these cones are remarkably steep-sided, and it is evident that the outpourings of ancient lava of which they are built up were at no time of very great fluidity. At a period subsequent to the fissure-eruptions a later outburst destroyed in part the Pichu-Pichu, and in this cataclysmic fashion was the great depression originally formed, in which Salinas now lies; the difficulty of picturing the ancient aspect of this region is enhanced by the excessive erosion, due to atmospheric and other agencies, that has since taken place. Evidences of solfataric action, which generally succeeds the more violent phases of vulcanicity, abound; and the native inhabitants of these parts work veins of extremely pure sulphur, which forms the infilling of contraction-fissures in the lavas, finding a market for it in Arequipa.

The centre of the depression has been to a great extent a receptacle for the detritus resulting from the atmospheric and aqueous erosion of the surrounding ridges, and the thickness of sedimentary deposits there must be enormous. The quantity of water that flows into this basin has diminished greatly of late, and the so-called "lagoon" presents a dry expanse for the greater part of the year, and can be traversed practically dryshod except in the rainy season. It is said, however, that only a decade ago, there was always water in the lagoon. The borax occurs near the surface of the sedimentary deposits in a discontinuous bed of extremely variable thickness. The average section, in descending order, is described as follows:—Superficial crust of sodium-chloride and sodium-sulphate; fine sand, 4 to 6 inches; coarse sand, 2 inches or more; sand with "seams" of borate, 8 to 20 inches; fine sand, thin, sometimes absent; seam of borate of variable thickness, averaging 16 inches, and attaining sometimes a maximum of 3¼ feet. Of course the crust of chloride and sulphate enters into solution when there is water in the lagoon, and as it dries off, these salts re-crystallize into a white crust covering the entire surface. The common salt, crystallizing out separately from the sulphate, is in part collected and sent to Arequipa. The

borate is defined as a boronatrocalcite or relexite, containing 30 per cent. of boric acid as got from the deposit; the dried material, freed from most of the combined water, may contain as much as 52 per cent. of boric acid. The purest relexite is distinguished, on account of its silky appearance, as *sedoso*, while the mineral which is more heavily charged with water and impurities is classified as "middling" (*corriente*). The seam of borate is impermeable to the waters welling up from the underground springs, and those portions of the lagoon where there is no borax are consequently marked by permanent water-holes. When the lower part of the borax-deposit is pierced through the imprisoned water bursts forth. The capricious distribution of the deposit, which is by no means thickest at the centre of the lagoon, seems to imply that the boric acid was evolved from the ancient lava-flows irregularly, and that the borates now lie on the spot where they were originally precipitated. The boracic exhalations were contemporaneous with the upwelling of thermal springs, which have formed the plumbargentiferous infilling of certain lodes in the andesites of the ridges towering above the eastern margin of the lagoon. The borax is extracted from diggings about $3\frac{1}{4}$ feet wide and 10 feet or so long, whence it is carried by a light railway to the drying ovens: a highly resinous scrub, which grows in abundance on the neighbouring rocks, and is known as *yareta*, serves as fuel. The dried borax is taken by pack-animals (mules, donkeys, and llamas) to Arequipa; but this mode of transport hardly keeps pace with the output, and the building of, at all events, a cable-railway from Salinas to that city is imperative.

L. L. B.

MINERAL RESOURCES OF THE DEPARTMENT OF CUZCO, PERU.

Aspecto Minero del Departamento del Cuzco. *By* Enrique J. Dueñas. *Boletin del Cuerpo de Ingenieros de Minas del Perú*, 1907, *No.* 53, 194 *pages and* 4 *plates.*

This department, including no less than twelve provinces, is situated in the Andine region of Southern Peru, its northern frontier marching with Brazilian territory. It covers an area approaching 157,000 square miles, half of which only, it may be said, has been explored or is inhabited. The departmental capital, the city of Cuzco, has a population of about 18,000 inhabitants, and next to Arequipa it is the most important commercial mart in the inland regions of Peru. The department is covered by a network of rivers, and, what with these and what with certain large lakes, there is abundance of water available, both for irrigation and for the transmission of hydraulic power. From the harbour of Mollendo on the Pacific seaboard, the Southern Railway runs for 443 miles *via* Arequipa to Checacupe; the 65 miles of line which are to link the last-named station up with the city of Cuzco were under construction at the time of writing. The topographical relief of the area described in this memoir is varied in the extreme; igneous rocks occupy about one-third of the surface, the remainder being taken up by the stratified deposits, metamorphosed and unmetamorphosed. Andesitic eruptive rocks are a conspicuously developed feature of Cuzcan geology, and there is an undoubted genetic relationship between the red and green andesite-dykes of Vilcabamba, Chimboya, La Raya, etc., and the neighbouring deposits of copper, lead, silver, and nickel-ores. The sedimentaries include slates and quartzites of probably Silurian age; limestones, sandstones, and conglomerates, supposedly Devonian or Carboniferous, with (according to some explorers) coal-seams at certain localities; marls, limestones, grits, etc., of

Mesozoic age, in places highly contorted and metamorphosed, and including workable deposits of gypsum and rock-salt; loosely-compacted Tertiary sands and conglomerates, with practically unworkable seams of impure lignite, and some beds (around Livitaca) of pure white tripoli; and finally Quaternary diluvial and alluvial deposits.

Scattered all over the department are the metalliferous deposits yielding oxidic and sulphidic ores of copper, iron, nickel, cobalt, zinc, antimony, arsenic, and silver, in such wise that it can hardly be said at present which is the predominating mineral. Gold, silver, and copper also occur in the native state; and the cupriferous and plumbiferous ores frequently contain silver and gold. Assays for silver of pure galena from four separate localities are cited, yielding from 3½ to 21 ounces of the precious metal per metric ton. Among the diorites deposits of red hæmatite abound, as also gold-bearing lodes, and occasionally the diorites [? decomposed] themselves contain sufficient native gold to make concentration in the *batea* worth while. The reported occurrence of tin-ores has no ascertainable basis in fact, and yet the abundance of granite with pegmatite-dykes in the Eastern Cordillera points to the possibility of stanniferous deposits being sooner or later discovered, in that district of the department at all events.

The author gives a detailed description of the metalliferous deposits, etc., province by province, beginning with that of Quispicanchi. Many of its rivers carry gold, and the district of Marcapata is especially renowned for its placers; but the difficulties of transport, in the absence of roads available for wheeled traffic, are great. A description is given of the gold-quartz lodes, the yield of which varies from *nil* to 15 ounces per ton; more space is devoted, however, to the placers in the Nusiniscato basin (Marcapata), which, it is said, would justify the investment of considerable capital for working them. Mica-deposits (muscovite) of commercial importance occur among the pegmatites of the Pumachanca district. The existence of lead-, antimony-, and copper-ores in the province is undoubted, but scarcely any prospecting-work has been done in regard to them.

From the province of Paucartambo, especially from the now almost exhausted placers of Churo and the vicinity, it is said that the ancient Incas drew much of their vast hoards of gold. In the shape both of auriferous quartz-lodes and placers, however, the province still promises a sufficient return to well-organized mining syndicates provided with ample funds.

In the province of Calca, more particularly in the Lares district, the predominant metalliferous deposits are lodes of silver-bearing galena and grey copper-ore, and occasional gold-quartz lodes.

Metalliferous lodes certainly occur in the province of Urubamba, the smallest of all the provinces in the department of Cuzco; but some thorough exploration-work needs to be done, before any reliable estimate can be formed concerning their value. Common salt abounds in the district of Maras, and is actively worked there.

The province of La Convención takes up more than three-quarters of the entire area of the department, and contains deposits of copper, lead, nickel, cobalt, zinc, and iron-ores, as well as gold and silver. Efforts have recently been made to re-open the ancient mines of Vilcabamba, where no less than fourteen lodes were worked. Communications are difficult, but native labour is cheap, and water-supply available for motive power, as also constructional timber, is abundant. The author describes in detail the fissure-lodes, which are in undoubted genetic relationship to the red porphyry-intrusions of the district, as follows:—(1) argentiferous grey copper-

ores; (2) nickel- and cobalt-ores; (3) argentiferous chalcopyrite, erubescite, etc.; and (4) argentiferous galena.

The province of Canchis enjoys the advantage of being traversed throughout its entire length by the Southern Railway, and is watered by two great rivers. After some reference to the ancient fame of the Chimboya district as a mining centre, to the stibnite-deposits of La Raya, and to various cupriferous lodes in the same region, the author gives a brief description of the gold-bearing quartz-reefs of Surimana and Sayhua, and then enters into some detail regarding his observations in the neighbourhood of Chimboya.

In the province of Paruro, there are some Tertiary lignite-deposits of no industrial value; but true coal is said to occur near Tahue, and the author saw fossil plant-remains from the neighbourhood which appeared to confirm the report. He describes briefly the argentiferous galena of Antapallpa.

The province of Chumbivilcas boasts certain deposits of anthracitic coal, discovered in 1902; they were, unfortunately, much charged with pyrites when the author saw them at Sihuinta. An average specimen of the mineral yielded the following analysis:—Fixed carbon, 42·47 per cent.; volatile matter, 9·84; hygroscopic water, 2·14; ash, 45·55. Heating power=3,600 calories. The extent, in area and in depth, of these deposits remains to be determined. In the same region there are considerable deposits of magnetic iron-ore (red hæmatite), evidently segregated out of the great dioritic intrusion which is the most characteristic feature of the geology of the province. A description is given of some of the gold-placers, wherein the native gold is invariably intermixed with a dioritic sand, and the bed-rock is diorite; also of the gold-quartz reefs which strike through the diorite, and have been so far untouched.

In the province of Canas magnetic red hæmatite occurs at several localities, as also cupriferous lodes; and argentiferous lead-ores are associated with the limestones of various districts. The author enters into some detail in regard to the iron- and copper-ores of Huine and Checca, and then describes the petroleum-bearing beds of Pallpata. He also speaks of the "petroleum-basin" of the high tableland of Titicaca, and gives in a footnote an account of the petroleum-occurrences in the province of Huancané (which, however, forms part of the department of Puno).

Señor José J. Bravo gives, in an appendix, a detailed description of nine specimens of minerals and of thirty-four rock-specimens. L. L. B.

MINERAL-DISTRICT OF HUANCAVELICA, PERU.

La Región minera de Huancavelica, Distrito de Huaillay, Provincia del Cerro de Pasco. By Carlos E. Velarde. *Boletin del Cuerpo de Ingenieros de Minas del Perú*, 1906, *No.* 44, 40 *pages and* 3 *plates.*

About 9 miles due east of the western Cordillera which separates the department of Junín from that of Lima, in the Cerro-de-Pasco province of the former department and 3 miles west-south-west of the township of Huaillay, lies the Huancavelica mineral-district, at a level of 14,700 feet or thereabouts above the Pacific. The country is one of ridges and lakes, rising gradually westwards from the Pampa de Junín to the great Cordillera. The distance by road from Huancavelica to the station of Casapalca on the Central Railway is something over 62 miles. The construction of a new railway linking up directly Cerro de Pasco with the seaport of Huacho, or with that of Chancory to the south-west of it, has been planned; but the

capital which this would necessitate does not appear to be forthcoming, as yet.

The author bases his account of the area on the information which he obtained in the course of two rapid journeys through it. The Huancavelica mineral-district is situated on an extensive anticlinal fold, the crest of which has been worn away and is now actually in its southern portion a depression occupied by the lake of Naticocha; to the northward rise the ridges of Jitga and Corpus, built up of eruptive dacites and highly contact-metamorphosed rocks, between which lies another depression occupied by the lake of Lacsacocha. Farther north still, the ravine of Huaichao has been carved out of the anticline, and in it appear dykes or apophyses from the eruptive masses just mentioned. The entire stretch of country, from the southern margin of Lake Naticocha to the vicinity of the township of Huaichao, is mineralized. The rock-succession, in ascending order, consists of marls; fine-grained pinkish-grey calcareo-ferruginous sandstones; coarse-grained sandstones, still with calcareous cement; tuffs—in part finely crystalline with chalcedonic impregnations, "in part devitrified," containing calcite, clay, and oxides of iron (probably as a matter of fact, an alternation of tuffs with decomposed submarine volcanic eruptives); these "tuffs" alternate with lime-cemented conglomerates containing huge quartzite-pebbles and undoubted basic eruptive rocks. The marls and sandstones appear to be either of Upper Jurassic or of very early Cretaceous age. On the east is a great ridge of acid rhyolites, seemingly barren of metalliferous ores.

The mineralized fissures extend over an area measuring more than 3 miles from north to south and 2 miles from east to west; they pass from the dacites into the sedimentaries and into the tuffs, with variations in strike and dip apparently dependent on the differences in hardness and other physical characteristics of the respective rocks. There is no doubt that these fissures are of later date than the dacitic eruption, and consequently of later date also than the formation and upheaval of the sedimentaries.

The thermal waters, percolating through the fissures, metamorphosed to some extent the walls thereof; and a series of chemical reactions was set up, with the result that the mineralization of the fissures in the sedimentaries differs from that of the fissures in the eruptives. This is exemplified by analyses showing the proportions of copper, sulphur, iron, manganese, arsenic, antimony, and silica to be much greater in the latter, and those of lead, zinc, lime, and silver much greater in the former: the rule does not, however, always hold good. Mining operations have so far not penetrated deeper down than the underground water-level of the region; but there is every reason to believe that further research will reveal secondary enrichment of the lodes, due to percolation of surface-waters and to the deposition of fresh sulphides upon those originally precipitated.

Towards the lake of Naticocha, in the southern portion of the area, the lodes range westwards through the sedimentaries, disappearing finally in the lake; but what are probably the same lodes reappear on the further shore. The lodes are all but vertical, and infilled with galena, blende, pyrite, chalcopyrite, and grey copper-ore, in a gangue of quartz. The Restauradora lode, for instance, varies in thickness from 3¼ to 10 feet, and an average sample yields about ½ per cent. of copper and 0·18 per cent. of silver. In the Jitga ridge, already mentioned, the lodes yield more copper and less silver. The Bellavista ridge contains a great number of lodes, among which may be noted the Tapoda, 3¼ feet thick, with pyrite, enargite, and other cupro-argentiferous ores, in a gangue of quartz; and the San Francisco,

with galena and but little copper-ore in a similar gangue. Between the lakes of Naticocha and Lacsacocha occurs the important lode of San Narcíso, the infilling of which is extremely variable, being in places highly cupriferous and elsewhere highly argentiferous. But the most extensive occurrence of copper-ores is in the Corpus ridge, mainly built up of eruptive rocks, now much decomposed. The lodes here form a vast network, although exploration and forewinning have been in the main confined to the Travieso lode, varying in average thickness from 3¼ to 10 feet, and attaining a maximum of 26¼ feet especially in depth, for the lode appears to be in the shape of a wedge broadening towards the base. The infilling consists of enargite, tennantite, and chalcopyrite in a gangue of quartz, with very little galena and blende. Assays of average samples have yielded maxima of 22·62 per cent. of copper and 0·11 per cent. of silver; while a parallel lode in which bismuthine and stibnite are associated with the copper-ores, yields 8·74 per cent. of copper and 0·13 per cent. of silver. The Productora lode in the same ridge is also of industrial importance; selected samples yielding as much as 30 per cent. of copper, and average samples 16 per cent. of that metal with 0·13 per cent. of silver.

Attention is drawn to the similarity presented by these occurrences with the ore-deposits of Morococha, in the district of Yauli, province of Tarma, 50 miles away to the south-south-east, at the base of the same western Cordillera.

It is only within recent years that prospectors have directed their investigations to this district, but now exploration-work is proceeding apace. The activity of mining operations properly so called is, however, apparently hampered by the obstacle so frequently lamented in Peruvian memoirs, the need of solid capital. The ores worked within the last five years by the Concordia Company have been treated at the Santo Domingo smelter, which obtains its fuel from coal-seams cropping out in the immediate neighbourhood, near the boundary between the province of Cerro de Pasco and that of Tarma. These seams strike from north-west to south-east with a steep dip, and yield a long-flame coal which produces excellent coke.

Timber for mining purposes is not locally available; but hydraulic power could be cheaply obtained, bearing in mind the existence of the lakes and the great fall in altitude represented by the ravine which descends to Huaillay. It has already been pointed out that coal is to be got practically on the spot (the magnificent coal-seams of Oyón in the province of Cajabamba, 31 to 37 miles distant, yield coke of superior quality), the only difficulties in this regard at present being those of transport. Labour is cheap, and it would merely need a railway-line of about 22 miles in length to link up Huancavelica with the main line to Callao. The most immediate necessity is a Governmental cadastral survey of the area described. L. L. B.

MINERAL RESOURCES OF THE PROVINCE OF HUAMACHUCO, PERU.

Monografía Minera de la Provincia de Huamachuco. *By* Fermín Málaga Santolalla. *Boletín del Cuerpo de Ingenieros de Minas del Perú*, 1907, *No.* 51, 66 *pages, with* 1 *map and* 2 *plates.*

The aboriginal words *huaman chucu*, from which the name of this province is derived, signify "snow-cap": it forms a heart-shaped area of about 428 square miles, the longest boundary of which is determined by the great river Marañón for some 50 miles. Its western boundary is determined by the great

Cordillera of the Andes separating it from the province of Otuzco: almost parallel to this Cordillera, some 12 miles to the east, ranges another mountain-chain, including the generally snow-capped Huaylillas, in sight of which lies the capital city of the province; there is a third range, practically parallel to the second Cordillera just mentioned, and it may, therefore, be inferred that the topography of the province is sufficiently rugged. The country is traversed by a great number of streams, with a fall adequate in the mining districts to the establishment of hydraulic motors. Constructional timber is to be found in certain forests, and especially in the Condebamba valley (province of Cajabamba), at most 25 miles distant from the city of Huamachuco. There is a population of nearly 39,000 souls in the province, and native labourers prove easily adaptable to mining-work. Of the abundance and excellent quality of the coal to be got on the spot more will be said later on. Means of transport are, however, unsatisfactory and expensive, as the only ways of communication which the province at present boasts are pack-roads: the distance from the provincial capital to the present terminus of the branch-railway from Trujillo, at Menocucho (in the neighbouring province of Otuzco), is nearly 84 miles; thence it is a matter of 25 miles' railway journey to the harbour of Salaverry on the Pacific seaboard. The prolongation of the railway from Menocucho, now being surveyed by a government engineer, will reduce the length of the pack-road to be traversed by 30 miles.

After a general description of the geology of the province, the author proceeds to give an account of the metalliferous deposits. Dealing first of all with the plumbargentiferous ores of Sanagorán, a locality barely 10 miles north-west of the provincial capital, he states that they occur in lodes which cut across a series of sandstones with thinly-intercalcated shales, metamorphosed by the eruptive andesites of the neighbouring Cordillera. The workings, long abandoned, have been lately re-opened at the cost of much labour and pertinacity, and good exposures of rich ore have been found, despite the occasional huge cavities which attest the amount of ore that was got out in the olden days. An assay of ore from the Concepción or Arica concession shows it to contain 53·45 per cent. of metallic lead; 14·52 per cent. of antimony; 5·94 of iron; 5·84 of zinc; 18·06 of sulphur; about ½ per cent. each of copper and arsenic; and 1·2 of insoluble residue; the yield of silver amounts to 80 ounces or more per ton. About 3¼ miles south of the provincial capital is the hornblendic andesite-ridge of Cerro Negro, with a north-eastern spur of the same rock from which it is separated by the Chilligorán ravine. Here the silver-lead ores constitute partly the infilling of contraction-fissures in the eruptive rock: although the fissures exceed a yard in breadth, they are mineralized, so far as present investigations have ascertained, only over a breadth of 8 inches. The ores are sulphidic to within a very short distance of the surface, the gossan of metallic oxides being but thin. Actively worked at one time, and represented by tradition as extremely rich, these deposits appear to have been lately the object of spasmodic exploration-work, speculators being encouraged by the rise in the price of antimony. An average sample brought from the Hedionda mine in May, 1906, by the author, yielded on analysis: 24·96 per cent. of lead; 7·6 of iron; 7·78 of antimony; 4·5 of zinc; 27·43 of sulphur; 0·45 of arsenic; 0·2 of copper: and 27·08 of insoluble residue. The proportion of silver in the ore was rather more than 16 ounces per ton.

Some 3 miles east of the provincial capital is a rocky ridge which has been accidentally fashioned by erosion into the semblance of a bull (*toro*). From this the rich gold-bearing lodes of El Toro take their name; on the western flank are quartzitic sandstones, contact-metamorphosed by the augitic

andesites which constitute the eastern flank. Intercalated among the sandstones are seams of black bituminous shale. The lodes which course through the sandstones have a general east-to-west strike, a steep southerly dip ranging from 60 to 90 degrees, and a thickness varying from 1 to 5 feet. The oxidized gossan is of considerable depth, and is said to have been fabulously rich in gold. The sandstones are very crumbly, and highly decomposed in the neighbourhood of the lodes. More than 300 adits, albeit shallow, were opened up in these deposits, and from them came the great waste-heaps of débris observable on the western flank of the Toro.

The lodes which course through the eruptive rocks appear to have no definite strike or dip, they cross each other at all angles, those intersections being richest where the angles are most acute. On the whole, the fissures and lodes are lenticular or *en chapelet*, the alternation of "bellying" and "strangulation" being a consequence of the motions set up in the eruptive mass in process of cooling and contraction. In the case of these lodes the oxidized gossan is extremely superficial, and the sulphidic ores are struck a very few yards below the outcrop. A sample on analysis yielded 21·29 per cent. of copper; 17·59 of iron; 31·06 of sulphur; 3·63 of antimony; 3·95 of arsenic; 1·38 of zinc; 21·10 of insoluble residue; and over 482 ounces of silver per ton. This preponderance of copper and silver is not observed in the highly auriferous lodes which course through the sandstones, and it would appear as if the difference in composition of the country-rock did determine in this case a difference in mineralization. The depth of oxidized gossan in the sandstones, as compared with its shallowness in the eruptive rocks, is probably due to the greater permeability of the former to the downward percolating surface-waters: the eruptive rocks were kaolinized in process of decomposition, forming an impermeable crust. Certain of the lodes are described in detail, and it is pointed out that their wealth must indeed be great to have yielded as much gold as they have done even within the present decade, considering the wretchedly small scale on which they are worked (1,111 ounces of 22-carat gold in eleven years).

In the Serpaquino district various metalliferous ores occur: as, for example, the Carmen system of lodes, which dip 80 degrees eastwards and traverse from north to south a series of siliceous blue slates and underlying quartzites. The lodes average 3¼ feet in thickness, and present, disseminated in a gangue of quartz, veins of tetrahedrite or panabase, iron-pyrites, chalcopyrite, galena, and blende with 1½ per cent. (*sic*) of copper and rather over 16 ounces of silver per ton. The San Pascual lode, in the Culantrillo ridge, about 11 miles south of the provincial capital, 32 inches thick, has an infilling of quartz, marcasite, and magnetic iron-ore: it courses through eruptive andesites, and does not appear to pass from them into the adjoining slates and quartzites. The Laguna Seca ridge, practically a prolongation of the ridge just described and built up of the same rocks, boasts the Potosì lode, 4½ feet thick, with an infilling of quartz, and abundant pyrite and hæmatite yielding 15 per cent. of copper, but no silver. A few furlongs farther south is the San Antonio mine where, interbedded among the contact-metamorphosed slates and quartzites are two ore-bodies 20 inches thick, consisting of marcasite, pyrite, and chalcopyrite, yielding 3·75 per cent. of copper, but no silver. In the San Pedro ridge, 16 miles distant from Huamachuco, the California mine has been opened up on a lode consisting of pyrite and tetrahedrite yielding 5 per cent. or so of copper and 48 ounces or more of silver per ton. About 20 miles south of the provincial capital, the Confidencia mine is situated among the quartzites and slates of the Sugampata ridge; adits opened up in gossans of oxidic ores,

following the bedding for 660 feet or so, have struck the corresponding sulphuric minerals (panabase and pyrite). These ore-deposits assume the lenticular or bead-string (*chapelet*) form, and do not exceed 14 inches in thickness. An average sample of the sulphidic ores yields the following analysis: copper, 6·98 per cent.; lead, 7·59; iron, 11·22; zinc, 1·48; arsenic, 2·03; antimony, 12·61; sulphur, 8·37; insoluble residue, 49·72; silver, 225 ounces per ton.

The predominant rocks of the province, in regard to the extent which they cover, are the Cretaceous sandstones among which are intercalated the shales which form the roof and floor of the coal-seams. Outcrops of coal are innumerable, and the formation may be unhesitatingly correlated with the coal-bearing series of the neighbouring provinces of Cajabamba, Otuzco, Santiago de Chuco, and Patáz. The occurrence of anthracites is attributed to the metamorphism set up by the later andesitic intrusions. The best known seams are those of El Olivo, 9 miles or so north of the provincial capital, yielding a hard, compact, lustrous black coal which has long been used for metallurgical purposes. It burns with difficulty in the open air, but excellently well in furnaces with natural or forced draught. It contains 83·74 per cent. of fixed carbon, 6·8 of volatile matter, and 4·3 of water, leaves 5·16 per cent. of ash, and its heating-power is equivalent to 7,708 calories. The Olivo seams are between 6½ and 10 feet thick. Two seams occur at Sanagorán, 6½ and 8¼ feet thick respectively, yielding a coal similar in every respect to that just described. In comparison with the enormous extent of the outcrops, the coal-bearing strata of the province are and have been worked on a very small scale. L. L. B.

MINERAL RESOURCES OF THE PROVINCE OF SANTIAGO DE CHUCO, PERU.

Riquezas minerales de la Provincia de Santiago de Chuco. *By* Fermín Málaga Santolalla. *Boletin del Cuerpo de Ingenieros de Minas del Perú*, 1906, *No.* 46, 120 *pages and* 7 *plates.*

This province was carved out of that of Huamachuco in the year 1900, but its capital city, Santiago de Chuco, was founded close upon three centuries ago, in 1610. Of a shape which recalls singularly, on a very small scale, that of the Indian Peninsula, the province is separated on the east from the province of Pallasca by the Tablachaca river. The Western Cordillera, which ranges to the east of it, sends many spurs westwards into Santiago de Chuco, while farther west another mountain-chain ranges parallel with the Cordillera; the area may, therefore, be described as a mountainous one. The rainy season (from October to April) is characterized, not only by heavy rainfall but also by violent thunderstorms and hailstorms; while in the dry season (from May to September) there are very high winds and frequent frosts. Ranching is pursued on an extensive scale, and agriculture is making rapid progress. According to the route selected, the distance from the provincial capital to the seaport of Salaverry varies between 100 and 103 miles, for 25½ miles only of which is railway-transport available. There is telephonic communication with the capitals of the neighbouring provinces, and with Trujillo and Chimbote (from which localities the telegraph can be used).

The westernmost mountain-chain consists in its southern portion of hornblende-granites up to within a very few miles of the ravine of Ancos, and then give place to hornblendic and augitic andesites which continue up to the northern boundary of the province. Between this and the western flank of the Cordillera of the Andes lies a series of sandstones, shales, and limestones

of Cretaceous age, the first-mentioned including coal-deposits belonging to a great formation which extends over the departments of Cajamarca, Libertad, and Ancachs. Igneous rocks predominate in the province here described, and the folded and upturned Cretaceous sedimentaries are highly dislocated, faulted, and metamorphosed; and to this metamorphism is attributed the anthracitic condition of the coal-seams. At Angasmarca (one of the most important *haciendas* in the North of Peru) the ridges near the manor-house are built up of micaceous and hornblendic dacites, from which hot mineral springs burst forth.

All the mineral-deposits of the province fall within one of the three following categories: (1) lodes coursing through eruptive rocks, as in the districts of Quiruvilca, Aguiñuay, and Santa Rosa; (2) lodes coursing through sedimentaries, as in the districts of San Miguel and Mundo Nuevo; and (3) coal-deposits of Callacuyan, Chesamuday, Llaray, Hospital, and Angasmarca, all belonging to one and the same coal-basin.

Quiruvilca takes its name from the native words *queru* and *vilca* signifying "teeth of silver." The infilling of the lodes being of a more resisting nature than the country-rock, the outcrops stand out like walls above the surface. The district lies on the continental watershed (*divortium aquarum*), at levels ranging up to 11,600 feet above the Pacific, 55 miles or so distant from the railway-terminus at Menocucho, and 22½ miles north-west of the provincial capital. The metalliferous lodes exhibit an inexhaustible variety of strikes and dips, with local enrichment at intersections, the enrichment increasing in the same ratio as the acuity of the angle of intersection. Some of the lodes have been traced for a distance of well nigh 6 miles; the zone of oxidation goes down to a depth of 50 or 60 feet from the surface, and the zone of secondary enrichment consists of pyrite which deeper down is enriched with enargite, tennantite, and tetrahedrite. Other constituents of the infilling are galena, blende, quartz, calcite, and barytes. It has been noted that enrichment as regards one metal takes place at the expense of another; thus lodes rich in silver are poor in copper, and *vice versâ*, and such variations may even be observed within one and the same lode. In some cases strings of native silver occur, arising from the oxidation of the sulphide to sulphate, and the precipitation of the latter by sulphate of iron. The thickness of the lodes varies between 3¼ and 10 feet, and is always less at the outcrop than deeper down; they are lenticular in form, and blende is comparatively abundant in some of them. Exploration-work has not been driven deep enough to pass through the zone of "sulphides of enrichment," and consequently no definite statistics are available as to the amount of ore in sight before the zone of poor sulphides is reached. These ore-deposits, but lately regarded as superficial and unimportant, are now estimated at their true value; and a new era is opening before the mineral-industry of Quiruvilca. Twenty-eight lodes are described in detail, and the following percentage analyses may be cited as fair samples of their metallic contents:—

Lode.	Silver.	Copper.	Iron.	Zinc.	Antimony.	Sulphur.	Lead.	Arsenic.
Yuracaco ...	0·16	18·9	34·5	2·8	1·5	35·9	trace	trace
Progreso ...	1·10	8·52	29·57*	12·87	2·64	35·56	7·43	trace
Vetilla ...	12·33	9·76	33·68*	9·72	0·86	36·96	1·20	1·43

* Includes alumina.

In Aguiñuay fine-grained augitic andesites predominate, kaolinized where they are exposed to atmospheric agencies, and especially in the vicinity of the metalliferous lodes. Mining operations have been suspended for so long a period that many of the workings have fallen in, and close investigation is

correspondingly difficult. Three lodes, however, are described in detail, and the following percentage analysis may be cited, of a sample from the San Marcos lode: zinc, 15·84; antimony, 3·26; iron, 18·93; arsenic, 5·3; lead, 2·52; copper, trace; sulphur, 25·95; insoluble residue, 17·77; water, 10·43; silver, 51½ ounces per metric ton.

The Santa Rosa ridge consists mainly of hornblendic andesites, and contains several metalliferous lodes, an average sample from which yields the following percentage analysis: antimony, 31·9; iron, 11·25; lead, 2·52; copper, 1·65; arsenic, 0·94; zinc, trace; sulphur, 32·46; and insoluble residue, 21·94. Working, hitherto conducted on a small scale, has always been profitable, and in 1905 133,800 metric tons of crude ore yielded 15,804 ounces of silver.

In the San Miguel district the lodes course through metamorphosed sandstones and shales, having an average thickness of 5 feet, with an infilling of tetrahedrite, bournonite, galena, blende, quartz, and gypsum. A sample of the ore yields the following percentage analysis: iron, 23·61; arsenic, 3·35; lead, 2·69; copper, 0·7; zinc, 0·99; antimony, trace; sulphur, 29·93; insoluble residue, 34·35; with traces of silver. On the other hand, it is stated that the average ore now worked does not yield less than 80 ounces of silver per metric ton.

The Mundo Nuevo lodes appear to vary in composition, according as they course through shales or through quartzites, as the following percentage analyses will show:—

	Lead.	Copper.	Zinc.	Antimony.	Arsenic.	Iron.	Sulphur.
Shale-lode ...	33·21	18·5	3·46	11·85	6·55	2·87	19·67
Quartzite-lode	17·66	17·3	3·46	7·59	4·80	9·52	21·14

The yield of silver varies from 81½ to 91½ ounces per metric ton.

The coal-seams of the province have been known for many years, but have been so far worked only superficially, on a small scale; and yet it is affirmed that they yield a mineral superior in quality to Pennsylvanian coal, and out of all comparison finer than Chilian coal. The seams are all anthracitic, contact-metamorphism set up by the andesites being assigned as the cause of this condition. The coal is of a lustrous black, hard, compact, of irregular structure. It burns with difficulty in the open air; but burns well in furnaces with natural or forced draught, and produces much heat. Distilled in a closed recipient, it yields a black coke of volume equal to that of the original coal. The following percentage analyses may be cited:—

	Fixed Carbon.	Hygroscopic Water.	Volatile Matter.	Ash.
Callacuyan coal ...	87·00	——	7·50	5·00
Callacuyan coal ...	92·39	——	5·67	1·94
Angasmarca coal ...	83·70	5·60	5·20	5·50

The heating power of Callacuyan coal is estimated as equivalent to 7,693 calories, and that of Angasmarca coal as equivalent to 6,965 calories.

The concluding twenty pages of the memoir are taken up with descriptions of the metallurgical treatment of the metalliferous ores. L. L. B.

COLORADO COALS, UNITED STATES OF NORTH AMERICA.

(1) *An Examination of some Coals from Routt County, Colorado.* *By* W. P. Headden.

(2) *A Comparison of some Coals from Boulder, Routt, and Delta Counties.* *By* W. P. Headden. *Proceedings of the Colorado Scientific Society*, 1907, *vol. viii., pages* 257-299.

The strata examined by the author in Routt County consist of Cretaceous sandstones and shales, with three series of coal-beds, separated by from

400 to 500 feet (estimated) of barren strata. The total thickness of workable coal seen by him was estimated at 25 feet for the upper series, 30 feet for the middle series, and 20 feet for the bottom series. Anthracite is characteristic of the middle series, and the anthracitazition of the coal is attributed to the metamorphism induced by basalt-intrusions; but admittedly the zone of metamorphic action is of small extent.

Eight analyses are tabulated of coal from the bottom series. The range in calorific value is from 7,445 to 7,806 calories; the fixed carbon varies from 50 to 57 per cent.; volatile matter from 35·5 to 39; moisture at 100° Centigrade, from 5 to 7; ash from 2 to 4. Ten analyses are tabulated of coal from the middle series; the variations here are considerable, as some of the coals are bituminous and others anthracitic (containing from 81 to 84 per cent. of fixed carbon). In comparing the coals of the middle and bottom series the author finds the latter to be somewhat the better, being richer in carbon, very nearly the same in hydrogen, and consequently poor in oxygen; the calorific values of the coals of the bottom series are also higher than those of the middle, the anthracites, of course, being excepted. None of the samples proved to be coking coals. Apart from the anthracites, the coals are classifiable as bituminous coals and black lignites, although the latter designation carries with it an implication of inferiority which the author considers unjust to the mineral concerned.

In the second paper three analyses are tabulated of coal from the South Platte field in Boulder County, representing a very high grade of the black lignites. They have a comparatively low specific gravity, high content of water, "slack" more or less badly in storage, burn with a short to medium long flame with but little soot, and give no signs of coking. The Routt County coals differ but little from these in their general characters and behaviour, but they do not "slack" to nearly the same extent. The heating power of pure Boulder County coal ranges from 7,074 to 7,087 calories, while that of pure Routt County coal attains a maximum of 8,322 calories. Three analyses also are tabulated of coal from the North Fork of the Gunnison River in Delta County. These are evidently coals of fair quality, containing in air-dried coal from 55 to 66 per cent. of fixed carbon, and yielding from 5 to 9 per cent. of ash; they are better than the typical black lignites, but probably inferior to the bituminous coals of Pennsylvania and West Virginia, on account of the higher percentage of oxygen determined in the ashless samples. L. L. B.

APPENDIX.

NOTES OF PAPERS ON THE WORKING OF MINES, METALLURGY, ETC., FROM THE TRANSACTIONS OF COLONIAL AND FOREIGN SOCIETIES AND COLONIAL AND FOREIGN PUBLICATIONS.

THE ZINC-ORES OF LA MALLIEUE (BELGIUM).

Étude de la Mine métallique de La Mallieue (Engis). *By* H. DE RAUW. *Annales de la Société géologique de Belgique*, 1907, *vol. xxxiv., Mémoires, pages* 125-139, *and* 1 *plate.*

The deposit of La Mallieue forms part of the Engis concession, worked by the Societé de la Nouvelle Montagne. It was the first to be worked of all the deposits included within that concession, and while mining operations have long been abandond on many of these, working still continues actively at La Mallieue. It is true that the operations begun in 1834, were suspended in 1840 on account of the exhaustion of the calamine (practically the only zinc-ore then worked); but mining was resumed in 1846, interrupted again in 1880 consequent on the flooding of the workings, and resumed again in 1882. An extensive pumping-plant now obviates all danger of flooding. Of late years much sulphidic ore has been extracted, and, the deposit betraying unmistakable signs of exhaustion, attention is being directed to unexplored portions, to masses left in the workings as supports, and to stuff left in place by the ancient miners as being too poor to repay working by the methods then in vogue. It must, in fine, be confessed that it is by dint of what may be called daily discoveries of fresh material that active mining operations still continue at La Mallieue.

Like most of the other metalliferous deposits which lie along the valley of the Meuse, the zinc-ores here are found near or at the junction of the Carboniferous Limestone with the Coal-measures. They occur in numerous pockets, which ramify and interdigitate in a remarkable manner, down to a depth of at least 700 feet below the surface. The general strike of the deposit here described is north-east and south-west, and the general dip is south-easterly.

The deposit is masked by a reddish-brown loamy sand with intercalations of brown plastic clay. The calamine (here defined by the author as a mixture of carbonate and silicate of zinc) was worked at the 150-foot level, but in the upper portions of the deposit limonite predominated to such an extent as to constitute a capel or gossan. The sulphidic ores include, besides blende, galena and marcasite (commonly known as "white pyrite"), the latter possessing a radiate fibrous structure. These occur in remarkably continuous concentric zones. The infilling of the ore-pockets exhibits really a breccii-form character, since angular masses of limestone and Coal-measure rocks are dispersed within the ore: immediately around these angular blocks there is invariably a zone of crystalline calcite, succeeded by narrower zones of pyrite

and (as a rule) dark blende. Without entering into details as to the further succession of zones within the deposit, it may be mentioned that the outermost metalliferous zone is a thick band of lustrous mammillated marcasite, which is encrusted by a final band of calcite, 6 to 8 inches thick.

The blende is extremely variable in colour and in texture; the galena generally well crystallized; and in the deeper portions of the deposit, crystals of gypsum are occasionally found encrusting the calcite. The blende now worked contains in the raw state from 14 to 15 per cent. of zinc, and from $1\frac{1}{2}$ to $2\frac{1}{2}$ per cent. of lead: as compared with the ores formerly worked, it is poorer in zinc, and slightly richer in lead.

With the ore-pockets are connected certain fissure-veins, probably corresponding to faults in the Coal-measures, and it is possibly along the prolongation of those faults that prospecting work directed to the discovery of as yet untouched ore-deposits might prove successful.

The history of the formation of the deposits is sketched out as follows:—Fissures opened up in the plicated and overthrust Palæozoic rocks, traversing the Coal-measures, the Carboniferous Limestone, and perhaps the Devonian rocks, formed channels for deep-seated thermal waters charged with carbon-dioxide: in such materials as limestone the very passage of these waters enlarged the fissures, while, in the Coal-measure shales, the fissures being obstructed by crumbled rock, yielded a less easy passage to the waters, and these gradually decomposed the shales into clay which finally stopped up the fissures. The waters then accumulated along the junction of the limestone and the Coal-measures and "ate out" in the former sundry interbranching cavities. Meanwhile, meteoric waters acting on the portions nearer the surface, gave to each fissure the form of a deep funnel. Then possibly the sides of these cavities began to break in, filling them with angular blocks of various dimensions, while the waters were precipitating around these the metalliferous particles with which they were charged. It is noticeable that in depth there is considerable impoverishment as regards blende, and a slight enrichment as regards galena. L. L. B.

IRON-ORES OF THE FOREST OF LORGES (BRITANNY).

Sur l'Âge des Minerais de Fer de la Forêt de Lorges (Côtes du Nord). By F. Kerforne. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, 1908, *vol. cxlvii., pages* 1007-1008.

The forest of Lorges, in the department of the Côtes du Nord (in other words, the northern coast of the Breton peninsula), covers the greater part of an area of very ancient stratified rocks—pre-Cambrian, Devonian, and Carboniferous—hemmed in by the granitic masses of Quintin and Plœuc. The highly plicated Devonian strata are faulted against the pre-Cambrian, and the Carboniferous deposits appear to rest unconformably upon the denuded edges of the Devonian beds. The author's investigation has been directed to the disentangling of the various horizons in the Devonian of the area, with the result that he is able to prove that all the iron-ores which occur there are of Lower Devonian age. In the northern district (Le Pas, Bas Vallon) the ore-bands are intercalated among soft black clay-slates; while in the southern district (Butte Rouge, near Uzel) they have typical slates at the footwall, and typical massive quartzites at the hanging-wall. It is thanks to the evidence furnished by the fossils that the precise age of these strata has been determined.

In almost every locality the iron-ores are ordinary hæmatites; but at

Bas Vallon the ore is a mixture of magnetite and a variety of chlorite exhibiting oolitic structure (bavalite). In the latter case the neighbourhood of intrusive diabases is to be noted; moreover, in the slates among which the bavalite occurs, the chiastolite (characteristic of the schists associated with the hæmatite of Le Pas, for example) is absent. Hence it would appear that the Bas-Vallon slates are outside the metamorphic aureole of the granite, since the incoming of chiastolite in the slates of the other localities is an unmistakable sign of the proximity of the granitic mass. L. L. B.

CUPRIFEROUS AND NICKELIFEROUS DEPOSITS IN THE FRANCONIAN FOREST, GERMANY.

Die Kupferbergwerke und das Nickelvorkommen im ehemaligen Gebiete der Hohenzollern am Frankenwald. *By* ALBERT SCHMIDT. *Zeitschrift für das Berg-Hütten- und Salinenwesen im preussischen Staate*, 1908, *vol. lvi., pages* 531-541, *with* 1 *figure in the text.*

Into the diabasic region between the northern frontier of Bavaria and the principality of Reuss (younger branch) a tongue of Cambrian strata protrudes, in the neighbourhood of the small towns of Lichtenberg, Naila, and Steben, detaching itself from the narrow bands of strata of similar age which trend thither from the Thuringian Forest. Patches of Devonian and Silurian rocks occur in the close vicinity of the Cambrian, with broad sills of "greenstones" and "schalsteine." Moreover, in addition to the bosses and ridges of diabase, crags of proterobase are conspicuous features, as also fucoidal quartzites and richly coloured limestones. Considering the small extent of the area, its geology is sufficiently varied; clefts and fissures, the likely haven of ore-deposits, abound: and it seems, consequently, quite natural that the district should have been in very early days the scene of active mining operations. It was, in fact, from here that Charlemagne recruited miners for the Harz.

The first ore got in the district was a magnificent spathic iron; then copper-ores assumed an overwhelming predominance, while compounds of nickel were less abundantly obtained. In some few cases bismuth and cobalt-minerals, now much in demand but then little appreciated, were found; as also silver-ores. The cupriferous lodes have generally quartz as a gangue-mineral, and are mostly associated with the Cambrian strata; but sometimes they pass into the Silurian graptolitic slates. Other gangue-minerals present are calcspar, fluorspar, and barytes: and it may be observed that all the lodes strike from south-east to north-west. The principal ore appears to have been chalcopyrite, and then its decomposition-products: malachite, azurite, etc., and finally native copper. Not much is known regarding the nickeliferous ores, since the ancient miners attached practically no value to them, any more than to those of bismuth and cobalt. Nevertheless sufficient traces of all these have been found on the old heapsteads, where they were thrown aside as useless, to show that the nickel-ores at all events were by no means isolated occurrences of small importance. The fucoidal greenish-grey Cambrian clay-slates often assume a jaspery appearance, and become then the matrix of the spathic iron-ores, which, as might be expected, pass into red and brown hæmatites.

The various known lodes are enumerated; and it is noted that those of Hirschberg, containing good tinstone in abundance, were profitably worked for that ore during a period of 40 years or so. There is a tradition that certain streams in this neighbourhood were successfully washed for gold; and argentiferous galena was actually worked in the Dürrenwaide valley. In the course

of all these mining operations, the district was largely denuded of its primæval forest, but re-afforestation is now in full swing.

The chequered history of the mineral-industry of the area, which repeatedly passed in the Middle Ages from one ruler to another, is recounted in detail. Possession was given to Prussia in 1791, and transferred to Bavaria in 1810. Owing to various unfavourable circumstances, the attempted revival of the mineral-industry was finally abandoned in 1860 or thereabouts. On the other hand, the ferruginous springs which are associated with the ore-bearing fissures have made of Steben a flourishing health-resort. It remains to be seen whether some enterprising capitalist will reopen the great Friedrich-Wilhelm adit, driven by Alexander von Humboldt in 1794, with the view of getting the unworked nickel-ores. The entire district might repay prospecting for these. L. L. B.

THE EISENZECHE IRON-ORE BELT, GERMANY.

Das Ganggebiet des "Eisenzecher Zuges." By — Resow. *Zeitschrift für praktische Geologie*, 1908, *vol. xvi., pages* 305-328, *with* 17 *figures in the text.*

The district here dealt with is a hilly one, and the highest point of the ore-belt, the Plannenberg, is over 1,600 feet above sea-level. Longitudinal valleys are conspicuous by their absence, and the characteristically short hill-ranges owe their existence to the varying durability of the rocks of which the country is built up. The toughest of all are the quartz-reefs which stand out as bold crags on the Birkerley (altitude, 1,240 feet) and the Hoheley. Most of the area is clothed with oak-coppice, which is cut down every twenty years or so.

The first mining operations recorded in the district date back to the year 1495, and appear to have been continuous till 1883. In 1894 several hitherto independent concessions were absorbed in the "Eisenzecher Zug" syndicate, and now all the ancient adits and levels are inaccessible, with the exception of the deepest and most considerable, the Reinhold-Forster main level, the total length of which is said to exceed 4,700 yards. The output for the year 1905 amounted to more than 250,000 metric tons of spathic iron-ore and 15 tons of copper-ore; the number of workpeople employed averaged 920, whereof 700 worked below bank.

The sedimentary rocks of the district belong to the Lower Devonian Siegen Series (correlated by some geologists with the Taunus Quartzite and the Hunsrück Slates). Their superficial uniformity and the absence of any horizon sufficiently marked to serve as a datum-line have frustrated, until quite recently, all attempts to establish on a firm basis the stratigraphical geology of the Siegerland. Wherefore the author considers it necessary to enter into minute detail as regards these beds, with the view of determining their precise relation to the ore-deposits. The sediments are essentially argillaceous (flaggy clay-slates) and arenaceous (fibrous grauwacké-slates, grauwacké-sandstones, quartzites, etc.): they vary in hue from a whitish-grey to a deep bluish-black. This darkening is due to the dissemination within the rocks of extremely fine carbonaceous particles. Later basalts are the only eruptive rocks to be met with in the district.

It was at one time supposed that the sedimentary rocks had been intensely folded, but the evidence now adduced points rather to repeated and considerable faulting. All the same, a certain amount of folding into synclines and anticlines is evident, as also some grandly-developed overthrusting. The dip is generally steep, 60° or 70° south-eastwards; the average strike is from north-north-west to south-south-east.

Although the ore-belt has been repeatedly described, its relations to the country-rocks have not been hitherto investigated in sufficient detail to permit of correct conclusions being arrived at in regard thereto. The author holds, therefore, that he has good grounds, in the light of his recent exhaustive investigations, for redescribing the ore-deposits. The Eisenzeche ore-belt crops out at the surface along a distance of 1,600 yards or so, and the Römel ore-belt (1,100 yards or more in length) may be regarded as its southerly continuation. The northern extremity of the Eisenzeche belt is determined by a big fault. Its general trend oscillates to such an extent, that the strike ranges from north-north-west to south-south-east, its mean ranging between north-north-east and east-north-east. The invariable north-westerly dip, all but vertical in the south, decreases gradually northwards, but may be said to average 70 degrees. In the immediate neighbourhood of Eisenzeche itself the ore-body attains its maximum thickness of 100 feet, which decreases little by little to 3¼ feet as the belt is followed northwards. Judging from the heapsteads and from the mine-sections, the entire belt may be regarded as one great fissure, interrupted by innumerable faults which cut across it at various angles. The infilling of the lode is predominantly a pale-grey spathic iron-ore weathering brown, the only gangue-mineral being quartz. The ore averages 36 per cent. of metallic iron and 8 per cent. of manganese. Pyrite and chalcopyrite play a subordinate part; the occurrence of small quantities of galena and cobalt-ore is also mentioned. Near the surface the spathic ore is almost invariably altered to brown hæmatite.

Working is at present mainly concentrated in the 820-foot level on three great "chutes;" forewinning is being pursued at the 1,000-foot and 1,150-foot levels, but the prospects are less favourable than at the first-mentioned level.

There seems to be no doubt that the infilling of the lodes dates back to Devonian times, before the early Carboniferous mountain-building movements began. Thermal waters carrying carbonate of iron in solution welled up into the fissures, and as they cooled deposited their ferruginous and manganiferous particles: this process must have continued for an extraordinarily long period. There is also no doubt that the quartz was precipitated at a later period than the metalliferous ores. The author discusses, at considerable length, the evidence showing that the great fissure-lode was formed and infilled before the above-mentioned orogenic movements which initiated the faults that cut across it repeatedly. He then considers the effect which these movements and also the character of the country-rocks have had on the ore in regard to its varying richness and massiveness at different points. On the whole, the clay-slates are "more favourable to it" than the grauwackés: the latter, more easily fissured, gave at one time passage to upward-welling silicated solutions which in part displaced the spathic iron-ore by quartz. The character of the country-rock had also something to do with the dissemination of the sulphidic ores. A short bibliographical list (eleven entries) is appended to the paper. L. L. B.

SPECULAR IRON-ORE OF THE FICHTELGEBIRGE, GERMANY.

Eisenglanz und seine Verarbeitung im Fichtelgebirge. By ALBERT SCHMIDT. *Zeitschrift für praktische Geologie*, 1908, *vol. xvi., pages* 362-369.

Cognizant though it may be of the famous occurrences of this ore in Europe, the mining world seems to be all but of oblivious of the magnificent outcrop on the southern flank of the Ochsenkopf, a granitic mass near the

village of Fichtelberg in the Fichtelgebirge. This was for many centuries the object of a local mineral-industry; and even now the ore may be found sparkling in the very roadways, where the quartz among which it chiefly occurs is used as road-metal. But the ore is not confined to the vein-quartz which infills fissures in the rocks; it occurs in a remarkable dyke-granite (known as the Steinach Granite), and also in a highly hornblendic greenstone ("proterobase" of Dr. W. von Gümbel). The main quartz-vein strikes approximately north-east and south-west, and is accompanied by narrow quartz-stringers which are confined to the granite or to the boundary thereof. The shimmering iron-ore occurs in bands among the eighteen quartz-veins of the Gleisinger Crag (Ochsenkopf), varying in thickness from 1½ to 13 feet. The fact, however, that the ore is by no means exclusively associated with quartz is of significance in regard to its genesis. An ancient heapstead in the Hämmerlesgrund, on the eastern flank of the Schneeberg massif, between Leupoldsdorf and Vordorf (long regarded as a prehistoric tumulus), on examination by the author proved that specular iron-ore had there been worked in typical gneiss. Yet, despite the variety of rocks among which this specular iron-ore occurs, its origin remains in every case the same. Lines of weakness along the junctions, and innumerable fissures within the rocks themselves, favoured the circulation of thermal waters charged with metalliferous particles. But the process of sublimation is not entirely excluded, and it has been suggested that such deposits of specular iron-ore may be in part assigned to the sublimation of chlorides of iron under the decomposing influence of water-vapour at a high temperature, as expressed by the following equation:— $2FeCl_3 + 3H_2O = Fe_2O_3 + 6HCl$. A sample from the outcrop of the Gleisinger Crag yielded the following analysis: iron-peroxide, 95·16 per cent.; alumina, 0·9; lime, 0·26; magnesia, 0·15; silica, 0·05; combined water, 0·05; hygroscopic water, 0·02; and gangue, 3·35. In the thirties of the nineteenth century, when the mineral-industry was still flourishing hereabouts, average assays showed 92·3 per cent. of iron-peroxide (equivalent to 64·7 of metallic iron) and 7·43 per cent. of quartz.

The first systematic working of the ores is said to date from the year 1478, the climax appears to have been attained in the first decade of the nineteenth century, and the mines were finally abandoned about the middle of that century. The ores were melted locally, the fuel used being wood-charcoal. A revival of the industry (on a modern scale, however) is not absolutely excluded, but there is not much hope of it in the near future. L. L. B.

THE ALMÁSSZELISTYE ORE-DEPOSITS, HUNGARY.

Das Erzgebiet von Almásszelistye im Komitat Hunyad. By Karl von Papp. *Földtani Közlöny*, 1908, *vol. xxxviii., pages* 423-436, *with* 3 *figures in the text and* 1 *plate.*

Along the borders of Arad and Hunyad counties, between the Maros and Körös rivers, stretches a great belt of eruptive rocks which furnish matter of much interest to the mining geologist as well as to the petrographer. The greatest complexity, as also the richest occurrence of ores, appears to be concentrated in the area that lies between Almásszelistye, Almásel, and Kazanesd.

Kazanesd is already the centre of an active mineral-industry, pyrite more especially being worked at a profit. The rich lodes of Almásel have been opened up within the last few years, and forewinning is in progress on great masses of chalcopyrite; but the mineral wealth of Almásszelistye is, at present, only a matter of estimation.

The area with which the author deals is entirely occupied by eruptive rocks, the only sedimentary deposits being drift clays and rubble. The typical basement-rock of the neighbourhood of Almásszelistye is an ashen-grey, medium-grained diabase; the other rocks described include diabase-porphyrite, a "greenstone-like" (altered) diabase, gabbro, amphibolized gabbro-porphyrite, granitite, haplite, granitite-porphyry, quartz-porphyry, and granodioritic porphyrites (a younger series of eruptives, which break through the diabases and the quartz-porphyries). The age of this great series of eruptive rocks ranges from the Lower Trias to the Upper Cretaceous.

On the Dosuluf hill, south of Almásszelistye Church, 1,705 feet above sea-level, an adit has been driven for 165 feet south-eastwards into the spheroidal diabase. It cuts first a lode 4 inches thick, then one of double the thickness, and finally the main lode which also crops out on the crest of the hill: the ores are chiefly siderite, blood-red specular iron-ore, and scaly hæmatite. The Gornyilor mine is situated at an altitude of 1,050 feet above sea-level: a small adit, barely 33 feet long, is opened up entirely in ore (chalcopyrite, etc.). Even the decomposed outcrop of the ore-body is of industrial importance, as the following analysis of a typical sample will show: iron peroxide, 37·95 per cent.; silica, 34·12; metallic silver, 0·002; copper monoxide, 0·89; sulphur, 22·79; alumina, 1·25; lime, 1·80; and magnesia, 1·08. Whence the author considers that it may be calculated that the undecomposed vein-stuff will yield 6½ ounces per metric ton of metallic silver. The only analysis made from the lode itself was for copper, showing 6·25 per cent. of that metal. The main lode here is 20 inches thick, strikes east and west, and dips 60 degrees south-eastwards: it is the finest lode in the district, containing in its quartzose gangue, besides argentiferous pyrite, pure chalcopyrite. The zinc-ore mine of Kolibi is passed over with a brief mention, as also the rich Sztanyásza mine, yielding the same ore, together with copper-ores; the latter is the northern-most mine in the district. Several other deposits are mentioned, yielding chiefly pyrite (Orlici, Pleskuca, Plesuluj, Bajsásza valley). Samples from the Barbara mining district, on the boundary between Almásszelistye and Mikanesd, have yielded the following percentage results:—

	Pure Pyrite.	Cupriferous Pyrite.
Sulphur	51·65	43·52
Iron	44·95	44·19
Copper	0·07	3·45
Gold	0·0014	0·0012
Silver	0·0190	0·0170
Insoluble residue	3·30	8·82
	99·99	99·99

It is shown that, in the Almásszelistye district on the whole, the vertical extent of the ores is at least from 790 to 1,705 feet above sea-level; pyrite and chalcopyrite are characteristic of the deepest levels; chalcopyrite, galena, etc., of the middle levels; and at the higher levels siderite and hæmatite occur, with secondary encrustations of limonite and malachite. The ore-bodies are all lodes or veins, some thick, and others thin. The general strike varies between north-north-east and east. There is reason to believe that the lodes continue in depth; and, as the district is easily accessible—Almásszelistye is 7½ miles distant from Zám railway-station on the Maros-valley line—the conditions are favourable to the initiation of a profitable, if not very extensive, mineral-industry. L. L. B.

THE DOBSCHAU ORE-DEPOSITS (UPPER HUNGARY).

Die Erzlagerstätten von Dobschau und ihre Beziehungen zu den gleichartigen Vorkommen der Ostalpen. *By* K. A. Redlich. *Zeitschrift für praktische Geologie*, 1908, *vol. xvi., pages* 270-274, *with* 1 *figure in the text.*

The investigations conducted by the author have enabled him to compare sundry ore-deposits of Dobschau with analogous deposits in Lower Austria, Styria, the Salzkammergut, etc., and to postulate certain hypotheses as to the common origin of them all.

East of Dobschau, among sericitic schists (in reality highly metamorphosed quartz-porphyries) alternating with much-altered clay-slates, occur the metalliferous lodes of Hirschkohlung: these are mineralized with siderite, chalcopyrite, galena, white nickeliferous pyrite, fahlore, cobalt-ore, etc., strike east and west, and dip southwards at angles varying from 20 to 70 degrees.

North of Dobschau lies the municipal iron-ore mine of Massörter. Here a mass of diorite is overlain by an alternation of highly micaceous black slates and limestones: a portion of the last-named has been eaten out by ferruginous solutions from which siderite was precipitated, thus metasomatically replacing the limestone. Fragments of unaltered limestone are found involved in the siderite.

At Holopatak (or Rabenseifen) on the Göllnitz Water, are the siderite-mines belonging to the princely House of Koburg. The footwall of the lode consists of red and white brecciiform conglomerates, followed by a yellow sericite-schist; the lode itself, varying in thickness from 3¼ to 82 feet, strikes east and west, dips northwards, and coincides both in strike and in dip with the rocks among which it occurs. It is mineralized with siderite and ankerite, and some chalcopyritic impregnations which become more abundant towards the hanging wall. In order to avoid copper-impurities in the iron, this portion of the lode is consequently not worked. At the hanging wall are various schists which may be regarded as altered "greenstones."

It is shown that, from the Tyrol to Lower Austria, a series of quartz-porphyry sills can be traced, across the Lesser Carpathians into Upper Hungary, which are either ore-carriers themselves or are intimately associated with the occurrence of ore-deposits. In some parts of this vast area the more or less altered sills are conformably overlain by Werfen Shales (Triassic), and hence are regarded as of Permian age; but at the Erzberg and in the Kitzbühel Alps they are overlain by Silurian and Devonian rocks; while at Massörter, etc., the Carboniferous System is found to overlie uncomformably the quartz-porphyries, conglomerates, and breccias which lithologically are absolutely identical with the "Permian" ore-bearing rocks of Lower Austria and Styria. The notion that the sills belong to two different geological periods is rejected by the author, and he inclines rather to the belief that in the Dobschau district the Silurian, Devonian, and Carboniferous rocks have been bodily overthrust on to the Permian. L. L. B.

LIGNITE-DEPOSITS OF VAL DI BRUNA, ITALY.

I Terreni miocenici di Val di Bruna (Maremma Toscana) ed i loro Giacimenti di Lignite. *By* V. Novarese. *Bollettino del Reale Comitato geologico d'Italia*, *series* 4, 1908, *vol. ix., pages* 4-28 *and* 85-114, *and* 2 *plates.*

This memoir is preceded by a bibliographical list consisting of twenty-six entries, and ranging from the year 1843 to 1907.

The lignite-mines of Casteani and Ribolla are included in the great Miocene area of the Bruna river-basin, in the district bordering the Tyrrhenian

Sea known as the Maremma Toscana. The author hastens to add that there is no relation between the present hydrographic system and the former vast extension of the Miocene deposits in that region. In the hills which surround the Bruna valley on every side except the south, Permian rocks occur, overlain by Triassic shales and limestones and by cavernous limestones of Rhaetic age, on the east; while northwards and westwards Eocene shales and limestones predominate, with intrusive masses of diabase, euphotide, and serpentine. All these are overlain unconformably by the Miocene, which is itself partly masked on the hills by patches of Pliocene and by Quaternary trachyte-flows, and in the plain by various Quaternary sedimentary deposits. The oldest group of the Miocene formation in this region consists of an alternation of marine sandstones and marls: their outcrop at the surface is of small extent, but mining operations have revealed their occurrence below the lignite-beds over a considerable area; they are assignable to the Middle Miocene, and are generally known as the Perolla Sands. Apart from their outcrop, throughout the rest of Val di Bruna the strata which directly overlie the Eocene, or, as the case may be, the older formations, belong to the great lignitiferous series of conglomerates, sandstones, clays, marls, and limestones with lenticles and seams of lignite. The development and aspect of this series vary considerably from place to place, except near the base where it invariably consists of coarse conglomerates, diverse (it is true) in constituents and in cementing material. The highest member of the Miocene System in Val di Bruna consists of gypsum with the associated clays and marls, typically developed in the neighbourhood of Sassofortino. Near Roccastrada, alongside the Miocene gypsum occurs the gypsum associated with the Rhætic cavernous limestone, the latter having, perhaps not unnaturally, been confused with the former by some geologists. It is west of the Asina stream that the lignitiferous series attains its greatest development, its thickness in that area exceeding 1,300 feet. Mining operations, begun as long ago as the decade 1830-1840, and still actively pursued at the Casteani and Ribolla mines, have facilitated the complete investigation of the series. Details are given of various comparatively deep shafts, and it is shown that, despite the tendency of the beds to graduate one into the other, three distinct stages may be distinguished:—(1) the lowermost, consisting of red conglomerates and the associated pebbly sands and clays of undoubted littoral facies, whether marine or lacustrine; (2) the middle, wherein appear the lignites among conglomerates consisting of small elements, soft sandstones (molasse) and clays, with fossiliferous impure limestones and marls; and (3) the uppermost, consisting of *Cardium*-clays, etc. The two upper stages are of brackish-water or lacustrine origin.

The seams of lignite vary in number from place to place, but one seam alone is constantly worked, showing the greatest continuity and thickness of any: immediately underlying the *Cardium*-clays, it retains its original appellation of the "First Seam;" and in the Pozzo Toscano, including shaly partings, it is nearly 30 feet thick. Below it have been recorded five seams at least, but all so thin as to be of no industrial importance.

The first seam is often 20 to 26 feet thick without partings; at San Feriolo (including shaly partings) it attains a maximum thickness of 46 feet. Occasionally, a second, much thinner, seam occurs, rarely attaining a thickness of 3¼ feet; it has never been worked, as it is so discontinuous and so variable in thickness. The third seam is about 5 feet thick, and of the fourth seam the thickness is not stated. Such work as was attempted on the seams below the first, in the forties and fifties of the nineteenth century, was ultimately abandoned.

A brief description is given of certain other lignitiferous areas in the Maremma, including the middle portion of the Ombrone valley, Acqua Nera, Marsiliana, and Monte Bamboli, chiefly with the view of showing that the exposures in Val di Bruna illustrate more fully the complete sequence, from the marine Middle Miocene up into the Pliocene. A lengthy discussion as to the exact age of the lignites is followed by an equally lengthy disquisition on the tectonics of the district.

The Casteani and Ribolla lignites are pitch-black, and in many respects resemble some meagre long-flame anthracites. Four analyses of these lignites are tabulated, as also four separate analyses of the ash and the associated shale. The heating-power ranges between 4,200 and 5,400 calories. Nothing is said as to the amount of mineral in sight. L. L. B.

DISCOVERY OF COAL IN MADAGASCAR.

Découverte de la Houille à Madagascar par le Capitaine Colcanap. *By* MARCELLIN BOULE. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, 1908, *vol. cxlvii.*, *pages* 818-819.

In March, 1908 the author had announced to the Academy of Science in Paris that Palæozoic strata certainly existed in Madagascar, basing this assertion on the find, in the basement sedimentary series of the south-western portion of the island, of a small fossil reptile analogous to the Permian forms of the continent of Europe, and also of an impression of an undoubted *Glossopteris* leaf.

Captain Colcanap, having, at the author's request continued his investigations in that area of Madagascar, Dr. Boule was able to announce in November, 1908 the discovery of coal-seams varying in thickness at the outcrop from 12 to 20 inches. They occur in the sedimentary series which occupies the basin of the Upper Onilahy (Mangoky), in the neighbourhood of Benenitra. Near that locality basement-conglomerates are exposed, containing enormous blocks identical with those described by Dr. Molengraaff in the Transvaal. There is, in fact, considerable analogy between the Madagascar deposits and the measures of similar age in South Africa.

The author points out that a discovery which may prove to be of great industrial importance is the logical outcome of the data furnished by palæontology, which too many persons are apt to regard as a purely speculative science. L. L. B.

THE DOMBROWA COAL-FIELD, RUSSIAN POLAND.

Materialien zur Kenntniss der Carbon-Ablagerungen des Beckens von Dombrowa. *By* S. J. CZARNOCKI. *Mémoires du Comité géologique de Russie, series* 2, 1907, *No.* 34, *pages i.-vi. and* 1-168, *and* 1 *map and* 6 *plates.*

This memoir embodies the results of the researches carried out by the author in the years 1904 and 1905. He explains the correlation of the Dombrowa Coal-measures with those of the neighbouring Upper Silesian Coal-field, and then adduces the data upon which he bases his estimate of the amount of coal in sight. He divides the coal-field into twenty-five districts, fourteen of which include the seams contained within the Reden or anticlinal group, while in the other eleven only seams that lie below the Reden Group are known. In the Reden Group, in District No. 1 (one of the poorest), there is a main seam averaging 33 feet in thickness, which "pinches out" in the eastern half of the Felix mine, and has so far not been proved farther east in the Dombrowa coal-field. The entire thickness of the other underlying and overlying seams

in this district averages about 23 feet. In the twenty-five districts the total amount of available coal is reckoned at 2,600,000,000 metric tons.

In the second part of the memoir the palæontological evidence is recorded, upon which the author bases his synopsis of the stratigraphical succession, tabulated as follows, in descending order:—

1. Coal-seams overlying the Reden Group.	Thin irregular seams of poor quality. Shales predominant. Thin bands of sphærosiderite.	
2. Measures lying between the bottom seam of the upper group and the uppermost seam of the Reden Group.	Coarse-grained sandstones, passing occasionally into conglomerates. Small lenticles of coal occur within the sandstone.	
3. Reden Group.	Western area.—Thick coal-seams. Medium-grained grey sandstones. Dark-grey slates.	Eastern area.—The great Reden Main Seam.
4. Saturn Series (best developed in the Saturn mine).	Thin coal-seams. Sandstones and shales equally developed. Grey medium-grained sandstones. Dark shales and grey sandy shales. In the shale next overlying the roof of the coal-seams isolated nodules of sphærosiderite occur. *Lingula* is a characteristic fossil in the eastern area, while in the western area there is a commingling of freshwater and marine forms.	
5. Flora Group (best developed in the Flora mine).	Thin coal-seams. Shales predominant. Dark clay-slates at the roof of the coal-seams, occasionally carbonaceous. At the floor paler shales. Sandstones. An upper horizon is characterized by *Lingula*, and a lower by a mixture of *Lingula* and a small contingent of typical pelagic forms with freshwater forms.	
6. Beds underlying the Flora Group.	Western area.—Pale-grey sandstones. Thin coal-seams (Strzižiwice series) occasionally showing a tendency to pass into natural coke (?). Shales poorly developed.	Eastern area.—Pale grey sandstones. Coal-seams absent.

In the Dombrowa coal-field two main folds are observed, both striking east and west; the southernmost is an anticline terminating on the borders of district No. 3, and the northernmost is a syncline, the southern limb of which coincides with the northern limb of the aforesaid anticline. There are two systems of faults, one coinciding with the strike and the other transverse thereto. L. L. B.

MANGANIFEROUS IRON-ORE DEPOSITS OF BROSTENI, RUMANIA.

Étude sur la Composition Chimique des Minerais de Manganèse et de Fer, qui se trouvent dans le Massif cristallin de Brosteni. By V. C. Butureanu. *Annales Scientifiques de l'Université de Jassy*, 1908, *vol. v., part* 2, *pages* 1-22, *with a table of analyses.*

The north-western portion of Moldavia, comprising the districts of Suceava and Neamtz, is largely occupied by crystalline schists, forming what is known

as the Brosteni Massif. Manganiferous iron-ores occur at several localities in this massif, and but few of them have been thoroughly investigated. Prof. Butureanu in this memoir devotes his attention to the most considerable deposit, that of Dealul Ferului. This occurrence seems to have been at least suspected (as the name of the place indicates) more than half a century ago, and at one time or another some attempt must have been made to work it: near the entrance to some fallen-in workings the author found a great heap of extracted ore of first-rate quality (containing as much as 80 per cent. of manganese dioxide), masked by a few inches of loose soil and also by young forest-growth. The deposit appears to cover the greater part of an area defined by the river Bistritza on the south and an irregular line on the north; by the Holditza valley on the west and Pârâul Ferului on the east.

The methods of chemical analysis adopted by the author are discussed in some detail, and he tabulates the results of his work on seventeen samples of ore, to most of which he applies the (apparently new) mineral-name brostenite. The percentage of metallic iron therein ranges from 1·3 to 25·9, and of metallic manganese from 56·34 to 15. The percentages of phosphorus are very low, and there appears to be no doubt that some of the ores would be of great value in metallurgy. The deposits here dealt with are doubtless secondary; the question to which the author addresses himself is, where and what are the primary deposits from which they were derived? He found in 1907, near an old working, great blocks, the more or less thick black crust of which consisted of oxides, but the core of undoubted rhodonite. Then, at another locality (Dealul Rusului) he found blocks of pinkish-grey to rose-pink rhodonite, with only a very thin crust of black ore. He has examined specimens of these in the laboratory, and infers the existence at considerable depths of enormous deposits of iron- and manganese-carbonates, more or less intimately intermixed with silicates of the same metals. At some remote period, owing to orogenic movements, these were brought sufficiently near the surface to become influenced by various erosive agencies, the particles swept off from them being altered to oxides, etc., and forming secondary deposits at localities whither they were transported by water. But, in some cases, there was no water-transport, and alteration to a greater or less depth took place *in situ*. In this and similar fashion are explained the varied aspect and character of the oxidic ore-deposits.

The streams in the district have a sufficient inclination and flow to furnish water-power for electrical installations. Timber, building-stone of various kinds, lime, and sand are easily accessible, and there is an abundant supply of labour. The sole disadvantage is the backward condition of the ways of communication. L. L. B.

ZIGAZA AND KOMAROVO IRON-ORE DEPOSITS, SOUTHERN URALS.

Recherches géologiques sur les Gisements de Fer de Zigaza et de Komarovo (Oural méridional). *By* L. Koniushevsky. *Mémoires du Comité géologique de Russie, series* 2, *No.* 21, 1906, *pages i.-v. and* 1-86, *with* 21 *figures in the text and* 2 *maps.*

The eastern portion of the region here dealt with is occupied by Lower Devonian strata; all the highest ridges are built up of quartzites and grits, which are geologically succeeded by more or less siliceous slates. The last-named are traversed by dykes of diabase striking approximately north and south. Most of the known deposits of brown hæmatite occur among the slates, but in the vicinity of the village of Bakeyeva the ores are found among the quartzitic grits.

The upper group of the Lower Devonian in this region consists of compact or fine-grained limestones occasionally dolomitic; among these are intercalated grey or greenish slates. The Middle Devonian hereabouts is divisible also into two groups: (1) the lower, consisting of very thinly-bedded red marls at the base, which pass up into similarly bedded greenish-grey marls and dark-grey limestones, these being in turn overlain by micaceous grits and red and greenish-grey slates; (2) the upper, consisting chiefly of grey limestones of variable character and texture. The Middle Devonian occupies the western portion of the region, and is traversed by two great longitudinal faults; the Lower Devonian of the eastern portion is much folded—the existence of faults therein is undoubted, but they are of less extent than in the west, and indeed are often concealed.

The ore-deposits are practically confined to the Lower Devonian slates, as above hinted, and are generally found on slopes of slight inclination or on the comparatively flat summits of small eminences. They are as yet almost untouched, and the deepest working or section known does not exceed 35 feet. In a great number of the deposits the ore-body is in the form of beds extending in a direction sensibly parallel with the meridian; elsewhere it is in the form of pockets or of irregular accumulations showing no trace of bedding. With regard to the genesis of the ore-deposits, it does not seem by any means certain that they all originated in the same way. Probably the "bedded" ores are the outcome of chemical alteration of the calcareous slates and limestones; others possibly were formed by the percolation of ferruginous solutions into rock-fissures, and the precipitation of the metalliferous particles owing to the oxidizing action of the air contained in the surface-waters.

The principal ore is a brown hæmatite, compact in some places, cavernous in others. The percentage of peroxide of iron therein ranges from 66 to 82, the average being 75. Deeper workings alone will show whether the ore-bodies, much diminished in value near the surface by the frequency of "horses" and "riders" of quartzite, grit, etc., improve lower down through the absence of these. At all events, the borings put down through the "Main Bed" at Komarovo, one of which has attained a depth of 154 feet, have shown that lower down the ore there becomes purer and richer in iron. With regard to the amount of ore in sight, it has been calculated that at Komarovo, for every 7 feet in depth, there are 2,000,000 metric tons available; at Zigaza, for every 7 feet in depth, 580,000 tons, and on the Bashkir estate 180,000 tons.

L. L. B.

IRON-ORES IN THE SWISS JURA.

Die Eisenerze im Schweizerjura. By E. Baumberger. *Mittheilungen der Naturforschenden Gesellschaft in Bern*, 1907, *pages* 58-67, *with a section in the text.*

Brown iron-ores occur at extremely various geological horizons in the districts here dealt with. Beginning with the oldest, oolitic iron-ore deposits are intercalated among the marls and sandy limestones (*Murchisonæ*-beds) which overlie the *Opalinus*-clays of the Lower Dogger. These were formerly worked at several localities: at the typical locality of Grange-Guéron, three oolitic beds of iron-ore separated by brown limestones have a total thickness of 6½ feet, and the percentage of ore in the amount of stuff brought to bank amounted to 12. Similar oolitic iron-ores occur near or at the top of the Dogger.

The main bed of the Valangian Series (Lower Cretaceous), the so-called "reddish limestone," through the gradual increase there of concretions of brown iron-ore, passes into a limonitic limestone where the concretions [illegible]ing

together and becoming cemented by an iron-shot calcareous clay, pass into a true workable limonite. Such ores were most actively worked across the frontier in the neighbouring districts of France, along the Upper Doubs and around Nozeroy. Analyses of these French ores are cited, showing from 45 to 48 per cent. of iron peroxide.

The competition of foreign iron-ores has extinguished the Swiss mineral-industry, so far as regards the Jurassic and Cretaceous ores just mentioned, but the early Tertiary pisolitic ores are still being worked.

The Tertiary pisolitic ore-formation yields, besides the ores, refractory earths in the shape of fire-clays and quartz-sands. The iron-ores occur among clays universally known in the Swiss Jura as *Bolus*: these show every conceivable gradation, from a greasy plastic material to dry, friable clays containing particles of quartz-sand. It is at the lower horizons of these clays that the workable ore usually occurs, in the form of lenticles, stringers, and stockwork-like accumulations, the last-named occupying depressions in the ancient surface of the underlying Jurassic limestones. Shafts have not seldom been sunk to quite considerable depths without striking ore, and thus the entire mass of clay proves in places to be absolutely barren. It is customary to wash the crude ore, before sending it to the smelters, thereby reducing its mass by about one half. All ores now mined are got by underground working: the shafts still in use in the Delsberg or Délémont basin are sunk to depths of 138, 177, 350, and 416 feet respectively. All the ore from the Delsberg mines (some 12,000 metric tons annually) is smelted at the Choindez blast-furnace. It yields from 40 to 42 per cent. of metallic iron of excellent quality, containing infinitesimal traces of phosphorus, if any at all. Analyses of this pisolitic ore made at Choindez yielded rather more than 60 per cent. of iron peroxide.

The pisolitic iron-ore formation in far-remote ages mantled over the entire Swiss Jura, but vast stretches of it and the overlying later Tertiary deposits have been swept away by erosive agencies. The author explains the reasons for which these ores may be regarded as a secondary deposit. The occurrence of fragmentary bones of Eocene mammalia and the occasional presence of conglomerates undoubtedly point to transport by water. L. L. B.

GYPSUM-DEPOSITS IN THE METALLIFEROUS DISTRICTS OF TUSCANY.

Die Gipse des toskanischen Erzgebirges und ihr Ursprung. *By* B. Lotti. *Zeitschrift für praktische Geologie*, 1908, *vol. xvi., pages* 370-374.

In the coastal belt of the province of Tuscany gypsum-deposits occur at two widely separated horizons, namely, in the Rhætic and in the Upper Miocene. Quite exceptionally, and at one locality only, is gypsum in that region found in the Middle Lias and in the Eocene.

The Miocene (Sarmatic) gypsum is invariably associated with white flaky *Congeria*-marls (among which diatomaceous deposits are intercalated) and with bituminous clays. At Castellina in the Era Morta hills, and at Chiusdino, the lenticular deposits of gypsum enclose masses of white and banded alabaster, which is quarried for decorative purposes. At Saline (near Volterra), beds of rock-salt accompany the gypsum; and in the Val d'Elsa (near Siena), beds yielding sulphur are found with it. These two last occurrences are especially indicative of a particular geological horizon, which can be traced in the Romagna, thence into Calabria and Sicily, and farther afield in Spain, Galicia, Hungary, Rumania, and Persia.

The Rhætic gypsum is always associated with a cavernous, more or less dolomitic limestone, generally occurring in the lower beds thereof near the junction with the underlying Triassic and Permian shales; or in the upper, near the junction with the overlapping Eocene. The association of these gypsum-deposits with the cavernous Rhætic limestone is so widespread, and has been proved at so many localities, that there can be no question as to the existence of a genetic relationship between the limestone and the gypsum. The most important Rhætic deposits are at Carnocchio (near Volterra), at Roccastrada (in the hills of the Maremma di Grosseto), and at Chianciano (in the Monte-Cetona district). These three deposits are briefly described, and emphasis is laid on the indications which they yield of having been derived from alteration of the limestones which envelop them. This mode of origin is contrasted with that of the Miocene gypsum-beds, the latter being undoubtedly primary marine deposits, practically contemporaneous with the sediments among which they occur. The gypsum associated with the Middle Liassic limestone of Monte Zoccolino (in the vicinity of, nay, actually between, the sulphuretted thermal springs of San Filippo and Campiglia d'Orcia) is also an alteration-product, and the same statement holds good of the gypsum that occurs among the Eocene Nummulitic limestones of Carpineti.

The metamorphic origin of the gypsum-deposits associated with the Rhætic limestones of Tuscany being now beyond dispute, the question arises as to why the sulphatization is mainly confined to the Rhætic limestones. It may be observed, in the first place, that, in regard to locality at all events, there is a very intimate association between the gypsum-occurrences and the metalliferous ore-deposits. A cogent example of this is cited from the neighbourhood of Massa Marittima, in which district also at several places the junction of the overlapping Eocene rocks and the cavernous Rhætic limestone is marked by a quartzose iron-ore deposit which represents the gossan of deeper-lying sulphidic ores. A great mass of gypsum, certainly more than 13 feet thick, is associated with the antimony-ores of Casal di Pari, between Siena and Grosseto, close to the junction between the cavernous Rhaetic limestone and the Verrucano slates of Permian age; and many other examples are cited of the occurrence in that Rhætic limestone of metalliferous deposits, which, like the gypsum, are of later date than the limestone, that is, not syngenetic. Like the gypsum too, the metalliferous ores occur predominantly near the top or near the bottom of the limestone, rarely at other horizons therein.

The author arrives at the inevitable conclusion that thermal solutions, similar to those which leached out a considerable portion of the Rhætic limestone, precipitating originally metallic sulphides, from which the oxidic iron and calamine-deposits were ultimately derived must have originated the masses of gypsum by the alteration of carbonate of lime into sulphate of lime. It is extremely probable, though not certain, that the formation of the gypsum was contemporaneous with that of the metalliferous ores. The thermal waters, charged with sulphurous and metalliferous particles, which made their way up through the fissures in the earth's crust in the region of the Tuscan *Catena metallifera* (or ore-bearing range of hills), found their easiest road in the Rhætic limestone:—they found in it moreover a material particularly open to chemical attack (in other words, to metasomatosis), and they remained in it the longer because it is both overlain and underlain by comparatively impervious formations (shales, slates, etc.). L. L. B.

BAUXITE-DEPOSITS IN EASTERN HUNGARY.

Neue ostungarische Bauxitkörper und Bauxitbildung überhaupt. By Richard Lachmann. *Zeitschrift für praktische Geologie*, 1908, *vol. xvi., pages 353-362, with 3 figures in the text and 1 plate.*

Bauxite-ocurrences have already been described at Remecz and Petrosz, but important deposits have more recently been discovered farther west in the Bihar mountains, in a limestone-massif covering an area of about 106 square miles, at altitudes ranging from 1,800 to 2,300 feet above sea-level. Although at first sight irregularly distributed over this plateau, the bauxite-deposits are seen to form three distinct groups: (1) a western, along the course of the Valea Mnierei; (2) a central, along the Cucu ridge, in the commune of Tizfaluhatar; and (3) an eastern, between the Valea Lucilor and the Valea Bratcalui.

All the aluminium-ores in this region occur among Jurassic limestones, predominantly as superficial accumulations which represent the result of weathering (bauxite-placers), but occasionally in the form of irregular lenticles which are primary deposits. The colour-contrast between the white limestones and the reddish-brown ores is very striking. The author explains in great detail the basis upon which he has established his calculation of the probable amount of ore in sight, which ranges from a minimum of 5,870,000 tons to a maximum of 18,700,000 tons. The importance of these newly-discovered deposits may be gauged from the fact that at present about 200,000 tons of ore are sufficient to meet the world's annual demand for aluminium. In regard to quality, the Hungarian deposits are in the first rank. Analyses of eight samples of ore from six different localities are tabulated, showing a maximum percentage of 63·07 of alumina. Iron peroxide is the next most important constituent, ranging from 20·34 to 30·8 per cent. A "standard" specimen of ore would yield the following percentages: alumina, 60; iron-oxides, 24; titanic acid, 3; silica, 1·5; and combined water, 11·5. Water-power for the treatment of bye-products of the ores is available within comparatively short distances. The manner in which the deposits occur permits of working by comparatively cheap methods, and the ores themselves are so pure that they hardly need any preparation for the market.

The author discusses at length Mr. Szadeczky's hypothesis in regard to the genesis of the ores, only to reject them, and claims that the aluminium was derived from the alumina originally contained in the limestones among which the ores occur. He pictures the process of their formation somewhat as follows:—A Mesozoic limestone-massif is postulated, exceeding 3,300 feet in thickness, overlying Palæozoic and Archæan schists; these were traversed by innumerable fissures, through which percolated upwards solutions containing sulphidic iron-ores. After the rocks had been saturated with these sulphides, what with high temperature and what with the nature of the country-rock, the sulphides were strongly oxidized. The sulphuric acid thus formed leached out the alumina from the clayey particles in the limestones, while the ferruginous constituents assumed the form of iron-hydroxide. Passing over the further details of the process, attention may be drawn to the classification of bauxites as (1) of metasomatic origin; and (2) of basaltic origin. The Hungarian deposits belong to the former group, and briefly may be defined as originating from felspathic rocks, or from their decomposition-products, by the action of sulphidic auto-decomposing ferruginous solutions.

L. L. B.

AURIFEROUS DEPOSITS OF THE YENISEI REGION, SIBERIA.

Carte géologique de la Région aurifère d'Jénissei: Description des Feuilles I.-8, I.-9. By A. K. Meister. *Explorations géologiques dans les Régions aurifères de la Sibérie*, 1908, *pages* 1-69, 1-43, *with* 2 *maps and* 2 *sections.*

The area described in these two memoirs lies between 58°40′ and 59° lat. N. and between 94° and 95° long. E. of Greenwich. It is an undulating country of smooth and rounded contours, where no prominent bluff or bold crag breaks the monotony—what relief there is, is due to the river-valleys. The greatest altitudes range from 1,650 to 1,970 feet above sea-level; and they recur along two lines trending from south-west to north-east, and coinciding with the principal rivers. In this area are practically included the head-waters of the hydrographic basin of the Southern Yenisei: the river-sources approximate very closely one to the other, and occupy a more or less central position in the area. The chief tectonic dislocations strike from north-west to south-east, while, as before hinted, the principal rivers run from south-west to north-east. One exception is furnished by the Uderei which changes completely its direction after receiving the waters of its tributary, the Shaargan. On the whole, the Uderei, the Ishimba, and the Udoronga river-valleys are transverse in relation to the general strike of the rocks of the country, and their tributary valleys generally cut across these diagonally.

The predominant rocks include: (1) schists of the Uderei type, consisting of an aggregate of quartz and white mica with a variable quantity of argillaceous material and containing cubical crystals of pyrite; (2) the overlying massive quartzites; (3) the "phyllites," containing finely granular pyrite, which the author regards as forming a series entirely independent of the Uderei schists, although passage-rocks from one to the other are observed; (4) ottrelite-schists; (5) granites, hornblendites, and calc-chlorite-schists; and (6), more rarely, dark-grey limestones and dolomites. Quartz-veins are of frequent occurrence, and in many places they contain gold. More especially are they found in a narrow fault-block, situated between the granites and the Borovaya and Bezimyanaya rivers, associated with outcrops of hornblendite. In this region occur the richest placers of the Southern Yenisei; and, though to all seeming worked out, they may yet furnish a fair amount of gold, especially if resort is had to dredging. They belong chiefly to the type of valley-bottom placers; the gold-bearing stratum varies in thickness from 4½ to 7 feet, and is richest in its lowest portion where it touches the bed-rock consisting of upturned schists. The overlying "barren bed" is of about the same thickness as the gold-bearing stratum, and the workings are generally opencast. The decomposed surface of the bed-rock is easily broken up by the miner's pick, and is generally washed with the alluvial material. The best placers are found in the upper portions of the valleys of the Uderei and the Great Murozhnaya, and here the bed-rock, instead of being schist, is often a plastic clay; this in some places has been bored to a depth of 42½ feet without reaching the hard undecomposed rock upon which it presumably rests. As the valley-sides are approached, the overlying barren stratum thickens to such an extent that underground workings are necessary to get at the gold-bearing alluvia, and in the Borovaya valley this procedure is followed even in the centre of the thalweg, close to the river. In the Krestovozdvizhensky concession, on the Great Murozhnaya, in the floor of the workings, which present a section 21 feet high, a shaft was dug showing the following descending succession:—talcose clay, 11½ feet; gold-bearing stratum, 4½ feet; plastic clay, 23½ feet; second gold-bearing stratum, 4 feet; talcose clay, 26¼ feet; and

third gold-bearing stratum, 7½ feet. Similar deep-lying placers may be expected to occur along the upper course of the Uderei where the bed-rock is also plastic clay. Of auriferous quartz-lodes, the Gerasimo-Fedorovsky mine, situated on the divide between the Great Murozhnaya and the Borovaya, and hitherto unworked, affords an excellent example. The author points out that what is known of these lodes justifies the hope that they will one day form the object of active and successful mining operations. L. L. B.

JURASSIC COAL-SEAMS OF THE BUREIA BASIN, SIBERIA.

Description des Itinéraires dans les Bassins de la Bouréia et du Niman. By A. Khlaponin. *Explorations géologiques dans les Régions Aurifères de la Sibérie: Région Aurifère de l'Amour*, 1907, *livraison vii., pages* 1-84 *and a map.*

The author encountered in his itinerary massive crystalline rocks (granites, haplites, diorites, quartz-porphyries, and hornblende-porphyrite); metamorphic rocks (gneisses, quartzitic and hornblendic mica-schists, and saccharoidal limestones); and sedimentary rocks (predominantly grey to black shales and yellow to smoky-grey ferruginous grits containing fossil plants of Jurassic age and fragments of belemnites). There are also post-Pliocene loams of inconsiderable thickness, and recent alluvial sands and gravels which form most of the eyots in the river Bureia.

Among the grits, and also between them and the underlying shales, are intercalated seams of coal, varying in thickness from a couple of inches to 3½ feet. The following samples are described: (No. 1)—less than 2 miles below the confluence of the Umalta, on the right bank of the Bureia, two seams (the lower 1 foot, the upper 2 feet thick) are conformably interbedded with the grits. The measures strike north-north-eastwards, and dip 10 degrees west-north-westwards. The coke obtained from this coal is pulverulent; the ash contains a great deal of silica and very little oxide of iron. The mineral is classifiable as a brown-coal, and has a heating-power of 6,290 calories. (No. 2)—A few furlongs up-stream from the winter-residence Ust-Nimansky, on the right bank of the Bureia, a coal-seam 18 inches thick crops out among the grits. The heating-power of the mineral=7,078 calories. (No. 3)—About 4 miles down-stream from Ust-Nimansky, also on the right bank of the river, a coal-seam varying in thickness from 2 to 3½ feet is interbedded with the grits. It strikes west-north-westwards, and dips 10 to 15 degrees south-south-westwards. The mineral yields a pulverulent non-agglutinating coke, and has a heating-power of 7,864 calories. It is classifiable among the "meagre coals"; the ash contains much silica and alumina, but little iron peroxide. (No. 4)—Some 2½ miles up-stream from the winter-residence Azanovsky, on the right bank of the Bureia, another coal-seam, 2 feet thick, is conformably intercalated among the grits. The mineral yields a slightly agglutinated and tumescent coke, has a heating-power of 6,752 calories, and is very comparable with the "meagre coals." (No. 5)—At a similar distance down-stream from the winter-station of Dublikan, on the left bank of the Bureia, a coal-seam attaining a maximum thickness of 2½ feet crops out between the grits and the shales. It strikes north-westwards, and dips 10 to 20 degrees south-westwards. The mineral yields a slightly agglutinated and tumescent coke, has a heating-power of 6,370 calories, and is classifiable among the "meagre" coals. The ash contains silica, alumina, and peroxide of iron.

Percentage analyses of these coals (in the dry state), carried out at the Imperial Institute of Mines in St. Petersburg, gave the following results:—

No.		Carbon.	Hydrogen.	Sulphur.	Oxygen and Nitrogen.	Ash.
1	...	35·78	2·94	0·45	13·09	47·74
2	...	51·86	1·37	0·12	7·56	39·09
3	...	73·93	2·25	0·31	6·44	17·07
4	...	65·34	4·64	0·92	17·27	10·83
5	...	65·34	5·31	0·70	22·81	5·84

The proportion of volatile matter ranges from a minimum of 9·39 in sample No. 3 to a maximum of 39·85 in sample No. 5.

It may be added that some of the venules of quartz that traverse the granites and the altered gneisses in a few localities in this area, as also the granites, the gneisses and the mica-schists themselves, have been sampled and analysed for gold, but with negative results so far. Nevertheless, the author holds that there is a reasonable hope of yet finding gold somewhere between the embouchure of the right branch of the Bureia and that of the Great Tastakh river. L. L. B.

MINERAL RESOURCES OF ANATOLIA, KURDISTAN, AND ARABISTAN.

Die Mineralvorkommen und die bergbaulichen Verhältnisse in Anatolien, Kurdistan und Arabistan. By Bruno Simmersbach. *Zeitschrift für das Berg-, Hütten- und Salinenwesen im preussischen Staate*, 1908, *vol. lvi., pages* 417-421.

The author has derived the material for this paper from a report submitted to the Imperial German Consulate in Constantinople by its commercial expert, embodying the results of the investigations conducted by him in the course of a journey through Turkey in Asia in 1907.

Anatolia is largely opened up by railways, and its geographical position and its numerous seaports are so many powerful factors in its favour in the struggle for industrial supremacy. Kurdistan, cut off here by deserts, there by big mountain-ranges from the sea, only communicates with outer civilization by long and precarious caravan-tracks: it is true that the river Tigris does constitute one possible route for exports. The vilayet of Aleppo, one of the exterior provinces of Arabistan, was opened up in the autumn of 1906 by the new railway from Beirut through Rajak, Damascus, and Homs, and is thus, more or less directly connected with the great seaports of Asia Minor.

Beginning the consideration of the mineral-deposits with those of Anatolia, it may be observed that workable deposits of chrome iron-ore, magnesia, and mercury-ores are of frequent occurrence in the vilayet of Konia, but have been hitherto grossly neglected. The most considerable mine at present worked in that region is at Bulgar Maden, where an argentiferous lead-ore is won and is bought up by the Ottoman Government at a fixed price. About a hundred irregular adits and drifts are driven into the hillside, and the operations are conducted in the most primitive fashion. Everything is at a standstill in the winter months, as the workings are then snowed up. The ores are smelted in seven furnaces in the neighbouring village fed with wood-fuel. The output therefrom in the fiscal year 1905-1906 amounted to about 155 tons of metallic lead and more than 7 hundredweight of silver. From that silver in Constantinople 11½ kilogrammes (or say 25 lbs. avoirdupois) of gold were separated out. The salt got from salt-lakes, etc., in the vilayet amounts to about 20 tons per annum. In the vilayet of Adana there are numerous occurrences of metalliferous ores and coal, the chrome-ore deposits being the most widely known. Cupriferous, argentiferous, and plumbiferous deposits

are reported, but the data are conflicting and uncertain. Salt is got in this vilayet also from lagoons, etc. The great plateau which constitutes the vilayet of Sivas is noted for the numerous alkaline, sulphurous, and chalybeate thermal springs which occur in its northern and eastern portions. The workability of the innumerable ore-deposits is not definitely established, but there appears to be little doubt as to the importance of the alum-beds of Kara-Hissar-Kharki and the argentiferous lead-ores at Kapa-Su-Kheiri, Kapakoila-Hissar, and the Sidjessi Mine, although the spasmodic attempts made to work the latter (and other plumbiferous deposits) have so far proved unsuccessful. Coal and magnesite are also said to occur, and marble, alabaster, etc., are abundant. Many projects for mining all these minerals have been put forward, and correspondingly many mining concessions have been secured, but roads suitable for wheeled traffic and accessible railway-lines are yet to seek. Salt it got in considerable quantity by evaporation from salt-lagoons, etc., and a bed of rock-salt (of rather poor quality) has been opened up. Angora, the central province of Asia Minor, is rich in minerals, many deposits having been worked in olden times. But the mineral-industry there is now in a state of suspended animation, although argentiferous lead-ores are known to occur at Ak-Dagh-Maden and Denek-Maden, associated with copper-ores at Elma-Dagh, and copper-ores alone at Muyalich. The vilayet is, moreover, rich in salt and in medicinal thermal springs.

The vilayet of Mamuret-ul-Aziz, the westernmost portion of Kurdistan, occupies very mountainous country, the character of which enhances the difficulties encountered by the prospector. Nevertheless, coal-seams have been struck at Palu and Chimikh-Kézék, whether workable or unworkable does not appear; and at Keban-Maden a silver-lead-ore mine was worked, so long as a sufficiency of timber and wood-fuel was conveniently available. In the equally mountainous vilayet of Bitlis, iron, copper, and lead-ores, also petroleum and ochre-deposits are known to exist; and the salt-output is quite considerable. The difficulties of transport are so great that, under the most favourable circumstances, goods take five weeks to reach the shores either of the Mediterranean or of the Black Sea. In the vilayet of Diarbekir the most important mines now working are those of Arghana-Maden, where the copper-ore is smelted in six furnaces fed with wood-fuel: the matter thus obtained contains from 75 to 80 per cent. of metallic copper. This is bought up by the Ottoman Government at so low a price, that neither the miners nor the lessees can make an adequate profit, and consequently the deposits are mined in a wasteful manner. In the same vilayet are the galena-mine of Tkil (yielding annually but 40 tons of ore) and the Hazzu coal-mines; salt is comparatively scarce.

In the vilayet of Mossul (Arabistan) quicksilver, lead, and copper-ores occur, but the numerous occurrences of naphtha and asphalt are far more important: these are worked in the most primitive fashion. In the vilayet of Aleppo an iron-ore mine is worked opencast at Marash; petroleum also is got and the occurrence of gold and of copper and lead-ores has been proved.

L. L. B.

THE SOUTH AFRICAN DIAMANTIFEROUS DEPOSITS.

Ueber die Südafrikanischen Diamantenlagerstätten. By F. W. Voit. *Monatsberichte der Deutschen Geologischen Gesellschaft*, 1908, *pages* 94-107, *and* 4 *figures in the text.*

The paper is preceded by a bibliographical list of the publications which have appeared on the subject since 1903, comprising fourteen entries. At

the very outset the author states that it may be regarded as settled beyond dispute that kimberlite, the matrix of the diamond, is not a clastic rock but a substance which has solidified from a fluid condition. He scouts, as absolutely contrary to common sense, the widely accepted theory that the kimberlite-dykes represent "explosion-fissures," back into which the eruptive material, together with fragments torn from the country-rock, is supposed to have fallen. Although the actual place of kimberlite in the classification of rocks is not as yet definitely determined, it cannot at all events be defined as a peridotite. The author describes it as a porphyritic pyroxene-olivine-mica rock, sufficiently close to the harzburgites to be regarded as an abnormal porphyritic micaceous variety thereof.

The author asserts, nor for the first time, that the kimberlite-pipes, so far from being open craters, are to be regarded as batholiths (adducing the cumulative evidence on which this assertion is based), and he even suggests the abolition of the term "kimberlite-pipe" in favour of "kimberlite-stock" (neck). He points out in how many instances the neighbouring rocks are seen to be upheaved, in some cases to verticality, by the kimberlite. The idea that all diamond-deposits are richer at the outcrop than at greater depths is incidentally characterizes as a fable. In fact, according to the testimony of many of those who are engaged in the working of the mines, there would appear to be enrichment concurrent with increase of depth from the surface.

On the whole, the author considers that it is proved that the kimberlite-dykes are tectonic fissures, closely associated with the tectonic disturbances of the rock-formations. They formed the lines of least resistance, along which the "kimberlite-stocks" (necks) made their way upwards. It would appear probable that the material did make its way upwards with explosive force; but the author admits that this behaviour on the part of a batholith is not very easily explicable. He thinks that two much stress can hardly be laid on the fact that the kimberlite in its initial stage was predominantly a pyroxenite, and says that it is very possible that kimberlite is mineralogically much nearer the eclogites than has been hitherto believed. He concludes that two stages in the crystallization of a molten magnesian silicate-magma may be defined: (1) crystallization beginning at great depths, resulting in the fragmentary formation of a rock mineralogically approximate to the eclogites, and (2) crystallization *in situ*, resulting in the formation of a porphyritic micaceous variety of the harzburgites.

The discovery of diamonds in eclogite-boulders has perhaps tended to lead observers astray as to the genesis of the precious gem, since it distracted attention from kimberlite as the probable matrix. Now, the author considers it proved that the diamond is a primary constituent of kimberlite. It would seem as if the circumstances attending the first or deep-seated stage of crystallization were unfavourable to the formation of diamonds; these mostly occur in the cementing material of the kimberlite, formed in the second stage of crystallization or final consolidation of the kimberlite-magma. Doubtless at this second stage, the upwelling of the magma was attended by the evolution of sundry gases, and, accepting the universal assumption that carbides are indispensable for the production of diamonds, these carbides must have been present in the gaseous form, saturating the magma. This hypothesis would fit in quite well with the genesis of inorganic carbon by pneumatolytic or hydatogenic processes in eruptive rocks. However this may be, the author regards as the most important result achieved the definite ascertainment of the fact that the diamond is a primary constituent of kimberlite; and he repeats with Dr. Stelzner that the carbon of diamonds belongs from its origin to

the kimberlite-magma, and that the diamond itself separated out from the molten magnesian silicated mass in course of the process of cooling.

L. L. B.

PETROLEUM IN THE ORANGE-RIVER COLONY.

Petroleum in der Orange River Colony (Süd-Afrika). *By* G. J. Kellner. *Zeitschrift für praktische Geologie*, 1908, *vol. xvi.*, *pages* 283-284.

It is among the basaltic and doleritic dykes which intersect the undulating plateaux of the Upper Karroo formation that the first traces of petroleum were discovered in this region. Among the highly pyritiferous basalt-dykes of the Harrismith and Bethlehem districts a tar-like bitumen was found, while the dolerite-dykes of the Ladybrand district yield a substance which on distillation gives off an unmistakable odour of paraffin.

The author is wishful, however, to direct more especially the attention of prospectors to the country lying along the Malutibergen and the Drakensbergen, at an altitude of 5,000 feet or so, including the Wepener, Moroka, Ladybrand, Ficksburg, Senekal, Bethlehem, Harrismith, and Vrede districts. Thus, at Clocolan, which is in direct railway-communication with Bloemfontein and Durban, beds of coarse-grained and fine-grained sandstone saturated with mineral oil have been found. Similarly favourable reports come from the neighbourhood of Senekal. Near Bloemfontein a boring was carried down to a depth of 885 feet, and although a greenish oil was actually struck the boring was ultimately abandoned.

A boring put down in the Ficksburg district to a depth of 295 feet was announced as unsuccessful, but natural gases were observed to escape from certain fissures, and there is reason to believe that more accurate knowledge of the stratigraphy of the Karroo formation might have led to a very different result.

One remarkable feature of the occurrence of petroleum in the Orange-River Colony is its frequent association with asphalt and sulphuretted thermal waters.

According to the most recent information, occurrences of ozokerite in sandstones and limestones, bituminous tuff, and porous sandstones impregnated with mineral oil have been found in the Ladybrand, Harrismith, Senekal, and Ficksburg districts, the most striking instances being recorded at Clocolan, Sherwood, and Ladybrand. The oil-field has been split up, by a number of eruptive dykes intersecting each other at right angles, into a series of isolated basins. The existence of a series of anticlines and synclines has been proved, and it is believed that the richest natural reservoirs of petroleum will be struck at depths ranging from 1,600 to 2,500 feet. L. L. B.

THE PETROLIFEROUS BELT OF NORTHERN PERU.

Informe Preliminar sobre la Zona Petrolífera del Norte del Perú. *By* V. F. Masters. *Boletin del Cuerpo de Ingenieros de Minas del Perú*, 1907, *No.* 50, *pages* 1-150, *and* 28 *plates.*

This study of the petroliferous belt is directed to the correlation of the coastal formations of the Province of Tumbes with the formations observed in the departments of Piura and Lambayeque. A preliminary synopsis is given of the so-called "anticlinal theory;" and, although its reliability is shown to have been triumphantly justified, its necessary limitations according to local conditions are duly emphasized. As the natural oils of Northern Peru are very diverse in quality, and as certain products of natural distillation

occur in that region which have been mistaken for coal, the author considers it advisable to tabulate a classification of the hydrocarbons known in nature, following in this matter the classification suggested by Dr. W. P. Blake, which is based on physical characteristics. They are subdivided into bituminous, resinous, and waxy substances, natural gas being at one end of the scale, and ozokerite and hatchettite at the other end.

The region in which the author's investigations were carried out is roughly divisible into (1) the coastal plain and (2) the hill-country. The former is occupied by Tertiary and post-Tertiary sediments which have been, to some extent, folded and faulted; the coast-line itself, and even the country for some distance inland, is characterized by a vast extent of dunes (blown sands). The hill-country is occupied by pre-Tertiary sedimentary deposits and by igneous rocks belonging to at least three different periods of eruption.

Five geological traverses are described, and then a comparatively brief history is given of the development of the oil-fields of Northern Peru, special attention being devoted to the Zorritos (first discovered in 1862), and the Lobitos deposits, actually on the shores of the Pacific (first worked in 1901). Various analyses, carried out in the United States and in Germany, of the petroleum from these areas are tabulated, as also of the Negritos oil (occurring on the coast some 15 miles south of Lobitos).

The stratigraphy of the Zorritos area is next described in detail, its predominant lithological character in the upper part of the section being the occurrence of sandstones of various grades of coarseness, varied by the occasional intercalation of an argillaceous stratum; while in the lower two-thirds red and dark brown clays, with lenticles of sand and occasionally conglomerates, are exposed. Then an account is given of the unsuccessful exploratory work initiated in the "Heath" ravine by a company which was formed in London in 1891, but finally suspended operations at the end of 1893; in 1895 a French company made an attempt to work the same deposits, and relinquished the task as hopeless at the end of 1897. The fact is, that the stratigraphical indications are by no means favourable in regard to the existence of workable oil-deposits in that ravine.

Seven other geological traverses are described, taking the reader southwards through Lobitos to Negritos, and thence inland to La Brea, where the abundant occurrence of natural gas (characteristic of the Peruvian oil-fields) is a good indication of the existence of great reservoirs of petroleum. At La Brea a heavy, black to greenish oil occurs, suitable in its crude state for purposes of lubrication. Several more traverses are described, covering the country southwards and eastwards to Vichayal, Amotape, Paita, Catacaos, etc. A description is also given of the sulphur-deposits of Reventazón, close to the seaboard, west of the desert of Sechura. Admitting a certain relationship between the Reventazón sandstones and the petroliferous horizons farther north, there is reason to infer the existence of oil-deposits in the Cerro Illesca which ranges north of Reventazón.

In summarizing the stratigraphical evidence, the author points out that, although the Lobitos and Negritos oil-bearing horizons belong to the same series of sands and clays, the horizons at which petroleum occurs in the Zorritos district cannot be satisfactorily correlated with them.

Tables of output and wages are supplied, and the dangers of competition (even in the local market) of the abundant and low-priced Californian petroleum are pointed out.

The penultimate chapter of the memoir consists of a description of the physiographical and geological features of the department of Lambayeque,

the coastal area of which is largely desertic. A brief account is given of the auriferous and argentiferous copper-ores of La Poderosa and San Ramón. The author concludes that the petroliferous formations characteristic of the department of Piura do not occur in that of Lambayeque.

L. L. B.

STANNIFEROUS DEPOSITS OF BOLIVIA AND PROSPECTING FOR TIN IN PERU.

Una Inspeccion de los Yacimientos de Estaño de Bolivia y una Exploracion por el mismo Metal en el Perú. By E. A. L. DE ROMAÑO. *Boletin del Cuerpo de Ingenieros de Minas del Perú*, 1908, *No.* 57, *pages* 1-99, *with* 28 *figures and* 2 *maps.*

The author was commissioned by the Peruvian Government to study the Bolivian tin-mines, with the view of thereafter investigating in the neighbouring provinces of Peru (Huancané and Chucuito) the possible extension of the stanniferous deposits.

Tin-mining in Bolivia is probably, although not demonstrably, an industry of ancient date. Its present development may be said to have begun in the thirties and forties of the nineteenth century, since when it has progressed and expanded with increasing acceleration as each decade rolled by. Bolivia now ranks second among the world's producers of tin, its annual output of the metal averaging some 15,000 tons.

The stanniferous deposits are scattered along the eastern Cordillera of the Andes, from 15° to 21° latitude S., the northernmost occurrence being that of Carabuco, about 22 miles distant from the Peruvian border, and the southernmost of any importance being that of Chorolque. This eastern Cordillera is a granitic axis, upon which rest Silurian and Devonian schists, slates, and sandstones, often highly metamorphosed. In the neighbourhood of the important mining centre of Oruro, the rocks are greatly dislocated, and have yielded passage to rhyolitic eruptions which have assumed the form of dykes and sills. The stanniferous lodes traverse the rhyolites and the neighbouring sedimentaries, but their association with the granites has not yet been proved. One of the most salient characteristics of the Bolivian tin-ore occurrences is, in fact, their association with Tertiary eruptives, instead of with ancient granulites. It seems likely that the orogenic movements which gave rise to the fissuring of the ancient rocks and to the eruption of the rhyolites took place in the Tertiary Era. The rhyolites are much decomposed in the vicinity of the tin-lodes, and apparently this alteration is due to the mineralizing solutions from which the metalliferous particles were deposited. Pseudomorphs of cassiterite after mica are not uncommon. The lodes vary greatly in thickness, rarely attaining a maximum of 4 or 5 feet, and the thinner lodes (less than 2 feet) are generally the richer: this will be understood when it is observed that the widest lodes assume more or less the character of a metallized breccia of mashed-up country-rock, instead of the clean, well-marked fissures infilled by the narrower lodes. Tin-lodes are also found in great numbers traversing quartzites: these rocks, forming a very resistant medium, were more cleanly fissured than the more yielding rocks at the time of the above-mentioned earth-movements. In the Cerro de Chualla, for instance, the main lodes traverse the quartzites, but lose all importance so soon as they pass from these into the clay-slates.

Prof. G. Steinmann, in his article in the *Mining Journal* (No. 3737) stated that the lodes are purer and richer in tin, the farther they are struck from

their point of origin; but the author holds that this statement is by no means of general application, and he adduces evidence which he considers tells against it. He notes the superficial enrichment of the stanniferous deposits, and observes that the tendency in Bolivia has been to limit exploration-work to the levels nearer the surface, further search being abandoned when the deeper zone of sulphidic ores was reached. Investigation of these deeper-lying ores is practically thrown back, therefore, on the mines formerly worked for silver which can hardly be ranged among the category of pure stanniferous deposits. The most considerable workings of the kind visited by the author are in the vicinity of Oruro; others, such as those of Antequera, actively worked at the time of the Spanish domination, are now practically abandoned, and the excavations have fallen in.

A detailed description of the mineral associations is followed by a general survey of the tin-mining operations now pursued in the region of Oruro and La Paz. The deposits in the vicinity of the former locality are nearly all linked up by good cart-roads with the narrow-gauge railway to Antofagasta. Water-power is not available, as the small streams running down from the Cordillera furnish barely enough water for the concentration of the ores. If sufficient capital, were, however, forthcoming, adequate power could be got from the more distant cataracts and lakelets of the Cordillera de Tres Cruces.

The price of coal at Oruro is at present prohibitive; but it would seem possible to make use of "explosion-motors," the necessary fuel being supplied by the distillation-products of the petroleum got from the Pusi deposits "on the lake-shore" (Titicaca), supposing that these prove to be of real industrial importance. Around La Paz the tin-mines are almost invariably equipped with hydraulic installations, which draw their supply from the great snow-peaks of the district. Nevertheless, hand-labour is used, to (what the author calls) an exaggerated extent, and is consequently expensive. The labourers are Aïraraes "Indians," much addicted to liquor, and, moreover, thievish and vindictive. The adits are generally near the hill-tops, where erosion had laid bare the outcrop of the lodes, and in most of such mines the crude ore is sent down by aërial steel-cables (telpherage) to the smelters in the valley below. Hand-drills are used for shot-firing, and the explosive universally employed is dynamite. In some few cases, where the ore occurs more especially among the decomposed rock, it is got by hewing with the miner's pick. Water-trouble is of such little consequence in the workings that, as a rule, pumping-plant is found unnecessary.

The Peruvian provinces of Huancané and Chucuito lie so near the stanniferous region of Bolivia, that the distance from the former of the Carabuco tin-mines and from the latter of the Oruro tin-mines is a matter of only a few miles. This proximity has, of course, suggested the idea that the ore-deposits would be found to continue across the border from Bolivia into Peru. Now, in Huancané, the acidic igneous rocks (with which stanniferous ores are invariably associated in both hemispheres) are conspicuous by their absence. It is true that in the very far north of it, a granitic boss is to be found; but a careful investigation has shown that not a trace of tin-ore is associated therewith.

The sedimentary deposits of Chucuito province are, on the whole, very similar to those of Huancané, but rhyolites are of frequent occurrence, and with them are associated silver, copper, and lead-ores, but so far not a single sample has, on assay, yielded tin. The author points out, however, that the province is of great extent, and that his investigations were much hampered by execrable weather. Still, making every allowance for possible omissions,

he holds that there is very little hope of stanniferous deposits ever being discovered there.

In Huancané occur the petroleum-deposits of Pusi, which give some promise of attaining considerable industrial importance. They lie on the north-western shore of the great lake Titicaca, very near Juliaca, the chief railway-centre of Southern Peru. The only copper-ore deposit of any importance is situated at such an altitude and in so remote a district that it could not be worked at a profit (at present prices). Under the Spanish domination Chucuito was the centre of an active mineral-industry, though not a single mine is being worked in the province now. It is true that some spasmodic and unsuccessful attempts in that direction have been made, but the author holds that the future prosperity of the province will depend on other factors than its mineral resources. L. L. B.

THE SULPHUR-DEPOSITS OF MAPIMÍ, MEXICO.

Geología química de los Criaderos de Azufre de Mapimí, Estado de Durango. By Juan D. Villarello. *Memorias de la Sociedad Científica "Antonio Alzate,"* 1907, *vol. xxvi., pages* 115-145, *with a list of errata.*

These deposits occupy a belt of some considerable extent in the State of Durango, and have been in places already worked to a good depth, while in other places working has been practically confined to the immediate neighbourhood of the surface. The two antagonistic theories in regard to their origin, which have hitherto held the field, are discussed at length by the author, and are both rejected by him. The first theory assumed that the Tertiary eruptions of the region here investigated were accompanied by the upwelling of thermal waters charged with hydrogen sulphide: these ate away the limestones through which they percolated, and the cavities thus formed were infilled with sulphate of lime, the result of the reaction between the hydrogen sulphide and the carbonate of lime in the rocks. This sulphate of lime was then decomposed by the reducing action of the organic matter contained in the limestones, with the result that free sulphur was liberated. It is unfortunate, from the industrial point of view, that neither chemically nor geologically will this theory hold good: for, if it were tenable, one might expect to find the native sulphur continuing far down towards the depths whence arose the supposititious waters charged with sulphuretted hydrogen.

The second theory presupposes two distinct phases in the formation of the deposits. In the first place, gypsum, silica, and finely pulverulent sulphur were formed; and in the second pure crystalline sulphur alone. In the former phase the thermal waters charged with hydrogen sulphide circulated among the fissures in the rocks: as these waters percolated upwards, the hydrogen-sulphide split up into water and free sulphur; the nascent sulphur was immediately oxidized to sulphur dioxide, which in part combined with oxygen and water to form sulphuric acid, in the presence of the organic matter contained in the limestones. This acid at once attacked the limestone forming the fissure-walls, containing a certain proportion of silicates and finely divided silica, and in this way sulphate of lime was formed and carbon dioxide liberated. The latter caused the excess of carbonate of lime present to decompose, and the solution thus formed in its turn leached out the silica and silicates from the limestones subjected to these repeated chemical assaults. A solution saturated with gypsum was the outcome, and when the saturation-point had been reached the gypsum was precipitated, owing possibly to cooling, to the evaporation of the waters, and to other physical causes. Later on,

the silicated solution in its turn reached saturation-point, and the silica was precipitated in conjunction with the gypsum. These deposits formed on the fissure-walls a practically impermeable crust, so that the organic matter contained in the limestones could not be leached out. This, as well as the diminution of the amount of oxygen in the air in the fissures, would prevent the hydrogen sulphide from being so far oxidized as to split up into free sulphur and water. Sulphur must have been deposited in the form of a fine powder upon the crusts of gypsum and silica. So much for the first phase. Then, supposing that the thermal waters became finally exhausted, but that the emanations of hydrogen sulphide continued, the latter on reaching the zone of oxidation would be decomposed with the formation of water and the liberation of sulphur. The nascent sulphur would recombine with the oxygen as dioxide, and this in coming into contact with hydrogen sulphide would again split the latter into free sulphur and water. This sulphur was deposited little by little along the fissure-walls, in the form of bands and also of separate crystals. The author refutes all these imaginary processes in the most vigorous manner, and points out that the industrial bearing of the second theory would be exactly the reverse of that postulated by the first: as the sulphur would only extend a little way down from the surface, being confined to the oxidation-zone.

In view of these contradictory results, the author propounds a third theory, based on his repeated investigations of the deposits *in situ*. The facts are as follows: the deposits are extremely irregular in form, occurring either in great pockets, or in narrow lodes, sometimes parallel one with the other, sometimes intersecting, among thickly-bedded bluish-grey limestones of Middle Cretaceous age. The infilling consists of gypsum, white pulverulent or colloidal silica, and native sulphur. The minerals occur in bands which pass gradually from one into the other, in the following order (counting from the fissure-wall): (1) almost pure gypsum, occasionally crystalline, in conjunction with limestone; (2) generally pulverulent gypsum with silica and sulphur, the volumetric proportion of the two last-named increasing as the centre of the lode is approached; and (3) in the centre, native sulphur, both crystalline and cryptocrystalline. Moreover, the sulphur occurs dispersedly in the infilling, especially in drusy cavities therein. The above-mentioned bands are very irregular in thickness, their respective development varying considerably from point to point within the same lode. There is no doubt as to the epigenetic origin of the Mapimí sulphur-deposits: that is, they were formed later than the "country-rock," across the bedding of which they are seen to cut. And they must have been formed at a comparatively low temperature: no signs of thermal metamorphism are apparent, and such minerals as karstenite and anhydrite (often produced by the dehydration which follows on high temperatures) are conspicuous by their absence. The non-occurrence of aragonite is also significant in this connexion.

The ascertained facts induce the author to believe that the sulphur-deposits were formed by exhalations of steam and sulphuretted hydrogen, escaping through the fissures in the rocks, and not by sulphuretted thermal waters. These vapours were, of course, associated with the andesitic eruptions; and they sulphatized and silicated the fissure-walls of limestone, the deposition of sulphur through the action of atmospheric oxygen being the ultimate stage of the process. The entire absence of metallic sulphides is another circumstance which tells against the hypothesis of origination from thermal waters; and the presence of basic sulphate of alumina in the adjoining limestone also disposes of any idea of acid-charged waters having played a

part in the genesis of the deposits. A series of chemical equations is tabulated, showing the probable course of events (two principal phases are recognized) in the formation of these deposits by the action of the exhalations of steam and sulphuretted hydrogen, and it is shown how these processes can have taken place at quite low temperatures.

Although present indications show a diminution of the sulphur in depth, it does not inevitably follow that this will be found to persist as the workings are pushed deeper down. It is quite possible that there is a "barren zone"—a portion of the fissure infilled by gypsum only during the first phase of sulphatization of the limestone—beyond which the sulphur may be struck again at depths where the vapours continued to circulate during the second phase of chemical reactions. But at the underground water-level of the country one must expect to meet with metallic sulphides (pyrite, cinnabar, and galena more especially) even if in small quantity. As the gypsum was in part simultaneously deposited with the sulphur, it is, on the whole, a good indicator for the latter in the above-described deposits. The intersections of fissures will prove most likely to be centres of enrichment as regards the native sulphur. L. L. B.

TIN-ORE DEPOSITS OF THE HERBERTON DISTRICT, QUEENSLAND.

Einige Bemerkungen über die Zinnerzlagerstätten des Herberton-Distrikts in Queensland. By W. Edlinger. *Zeitschrift für praktische Geologie*, 1908, *vol. xvi., pages* 275-279 *and* 340-343.

Queensland now stands at the head of the Australasian States as a tin-producer, and the greatest mass of her wealth in that metal is found in the Herberton district, which accounted for more than three-quarters of the total output of the State in 1906. The stanniferous deposits in that district extend over an area exceeding 965 square miles, a country which lies at an average height of 2,000 feet above sea-level, but is crossed in every direction by long narrow ridges culminating in altitudes of 5,000 feet or so. Nearly all these deposits occur along a belt which includes the Main Dividing Range, following it from south-west to north-east for some 30 miles or more. Here biotitic and hornblendic granites and porphyries predominate, enclosing island-like masses of grauwacké, clay-slate, and sandstone belonging to the admittedly Palæozoic Gympie formation. These sedimentaries have been fundamentally metamorphosed by contact-phenomena and dynamic action; their bedding has, of course, been considerably disturbed; they have been highly plicated, faulted, sheared, and thrust. Their general strike varies from north and south to north-west and south-east.

The metalliferous lodes are most surely found where granites come into contact with the slates; they are extremely irregular ore-bodies, but their small superficial extent and their impoverishment in depth (at about 330 feet down) are frequently compensated by their enormous thickness.

A deep level exceeding 100 yards in length (*e.g.*, the Lancelot mine) is somewhat of a rarity, as also the occurrence of rich masses of ore at such depths as 1,250 feet (*e.g.*, the Vulcan mine). There is no doubt that the lodes are the outcome of metasomatic processes which took place along lines of weakness and fissures in the rocks. The tin-ore and its associates are seldom found in the crystalline form: the former occurs in thick black or brown compact masses, though "ruby tin" and "amber tin" exhibiting concentric structure are not uncommon.

There is a marked distinction between the stanniferous deposits which are

confined to the slates, and those which are traced into the granites. Some of the former exhibit their characteristics as true fissure-lodes in their extreme regularity, and in the passage from a massive to a bedded and brecciiform structure. A typical example of such is the Lancelot Lode, 462 feet in horizontal extent, 344 feet in depth. It differs from the world-renowned Dolcoath Lode in the occurrence of masses of rich copper-ore occasionally taking up the whole breadth of the lode, which averages 1½ feet. It has been much disturbed by a series of faults striking east and west, which are the source of some difficulty in mining operations. The usual fluor and boron minerals associated with tin-ores are so far conspicuous by their absence in the Lancelot Lode.

The most considerable, and industrially the most important, stanniferous deposits of the district are associated with the slates, and are locally known as the "chlorite-stone deposits." Their outstanding features are the association of chlorite with tin-ore, the irregularity of the ore-bodies, and the manner in which they, as it were, melt into the country-rock. The typical infilling of such lodes is a dark-green, tough, finely-granular mass, known to the miners as "green chlorite-stone;" this passes by decomposition into a rusty brown ore ("red chlorite-stone") which occasionally is found to extend in a most remarkable way below the underground water-level.

With regard to the stanniferous lodes in the granites, the author holds that no true fissure-veins have as yet been proved, and that the ore-bodies are in truth the outcome of metamorphism of the country-rock, by a process comparable with the formation of *greisen*. He admits, however, that these elongated ore-bodies are possibly connected genetically with a system of fissures. The finely granular *greisen* among which they occur is an alteration-product of a granite, and forms very extensive belts, far more extensive than the actually workable ore-bodies. Among these are described those worked in Dalziell's mine, and in Hadleigh Castle mine (Dry River valley). The number of stanniferous lodes which course through the granite is indeed remarkable: they are scattered over the entire district, but for the most part have been actually worked out, or are practically regarded as exhausted. Others, however, especially around Herberton itself, have been the object of uninterrupted mining operations since the opening-up of the field, and still produce considerable quantities of rich ore; yet others probably await the touch of the prospector's magic wand to awaken to industrial life. These lodes are generally characterized by great wealth at the outcrop, and small extent along the strikes; they pinch or nip out usually at small depths, and yet some have been traced with undiminished yield down to a depth of 1,000 feet or so.

The age of all these primary ore-deposits is traced back to pre-Carboniferous times.

Alluvial and pre-basaltic stanniferous placers occur along all the streams which come down from the Main Dividing Range, whether the course of the latter be directed to the Gulf of Carpentaria or to the Pacific Ocean. The granitic areas have proved more favourable to the accumulation of tin-bearing rubble than the slate-areas. On the whole, the material of which the placers are composed shows scarcely any trace of bedding; the deposits range in thickness from 1½ to 16 feet, attaining at Smith Creek a maximum exceeding 33 feet. Gold is a rare associate of the tin-stone in the placers, and similarly auriferous lodes are scarce in the Herberton tin-ore belt. Although the presence of magnetite and titaniferous iron-ore has been proved in many placers, they never occur in sufficient quantity to be detrimental. In comparison with the stanniferous placers of New South Wales and Stanthorpe, those of the Herberton district seem poor enough; but then it must be remembered that

the richest have been worked out within the last decade or so. The ore got from these placers averages more than 70 per cent. of metallic tin, and consequently finds a ready outlet at the Irvine Bank smelting-works.

The pre-basaltic, so called "fossil" placers are not of widespread extent, and the working of them has proved far from profitable hitherto. They are practically confined to the course of the Wild River, at points where the ancient river (sensibly parallel with the present one) was dammed back into lakes by porphyry-dykes; the sediments then laid down were protected from denudation by later basalt-flows. These placers are situated at altitudes of 30 to 70 feet above the Wild River alluvium, and they rarely attain a maximum thickness of 23 feet; sometimes they are completely nipped out by basaltic flows. L. L. B.

THE FOSSIL PLANTS OF THE DOMBROWA COAL-FIELD, RUSSIA.

Beiträge zur Kenntniss der Fossilen Flora des Steinkohlenreviers von Dombrowa. By M. D. Zaliessky. *Mémoires du Comité géologique de Russie*, 1907, *new series*, *No.* 33, *pages* 1-69, *with* 10 *figures in the text and* 2 *plates.*

The Dombrowa coal-field in Russian Poland is but a small fragment of the great Upper Silesian or Polish-Silesian coal-basin, which covers an area of 2,000 or more square miles in German, Austrian, and Russian territory. The author follows Prof. Frech's and Dr. Potonié's recent (1899-1901) classification of the measures, the correlation being thus set forth:—

Productive Coal-measures or Upper Carboniferous	Middle	(8) Sohrau Beds (7) Nikolai Beds	= Upper Saarbrücken Series.
		(6) Ruda Beds	= Lower Saarbrücken Series.
	Lower	(5) Sattelflötz Beds	= Upper Sudetic Series.
		(4) Czernitz Beds (3) Loslau Beds (2) Hultschin Beds	= Lower Sudetic or Ostrau Series.
Lower Carboniferous	Golonog Beds.		

In a review of the palæobotanical literature of the subject, the author points out that the material in the shape of plant-remains so far obtained from the Dombrowa coal-measures did not justify, either by its quantity or by its preservation, any very positive statements as to the actual age of this or that particular bed. The rapid extension of mining operations had opened up new horizons to the stratigrapher, at a rate with which the palæobotanist could not hitherto keep pace. In the years 1904 and 1905, however, certain members of the Russian Geological Survey, who were directed to make investigations for the purpose of determining as far as possible the amount of coal which the Dombrowa coal-field might be expected to yield, gathered together a small collection of plant-remains from the coal-measures there. These were submitted to the author, and he was able to identify twenty forms, three of which are new to science. The three new species are, *Lepidodendron Tonderae* and *Polygonocarpus Czarnockii*, from the beds underlying the Reden seam; and *Sphenopteris Bogdanowiczi*, from the beds overlying the Reden seam. He identified also two known species of *Sphenopteris*, one of *Mariopteris*, one of *Neuropteris*, one of *Pecopteris*, two of *Sigillaria*, one of *Ulodendron*, three of *Lepidodendron*, two of *Sphenophyllum*, two of *Calamites*, one of *Asterocalamites*, and *Stigmaria ficoides*. The beds overlying the Reden seam are thus shown to contain a perfectly typical Saarbrücken or Westphalian flora, and may be correlated with the Schatzlar Beds in

the Austrian portion of the great coal-basin. On the whole, the evidence yielded by this small collection of plant-remains confirms in a general way the stratigraphical data: from the strata underlying the Reden seam have been obtained plants representative of Dr. Potonié's "Second Flora" (Lower Sudetic), and from that seam itself, or from the Sattelflötz Beds, plants representative of Dr. Potonié's "Third Flora" (Upper Sudetic).

The Sattelflötz group is typically developed at Zabrze in Upper Silesia, where it includes (in descending order) the following seams: Einsiedel (10 feet thick); Schuckmann (20 to 40 feet); Heinitz (13 feet); Reden (13 feet); and at the base the Pochhammer seams (16 to 20 feet). Eastwards, however, both the barren strata and the seams diminish gradually in thickness, wedging out in such a manner that the seams are first reduced to three, then to two, and finally to one which is 46 feet thick, and occasionally as much as 65 feet. Thus, in the extreme west of the Dombrowa field, two or three seams only are proved, while farther east therein there is but one seam, which is known as the Reden seam. From this horizon, the stratigraphers have built up their synopsis of the rock-succession in the Dombrowa coal-field; and, as above mentioned, their data are now confirmed by the palæobotanical evidence, comparatively scanty though it be. L. L. B.

GEORGIADESITE, A NEW PLUMBARSENIFEROUS MINERAL.

Sur une nouvelle Espèce minérale, provenant des Scories plombeuses athéniennes du Laurium. *By* A. Lacroix *and* A. de Schutten. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1907, *vol. cxlv.*, *pages* 783-785.

Quite a series of beautifully crystallized plumbiferous minerals have been described within the last decade, which owe their origin to the action of sea-water on the slag-heaps, rich in metallic lead and in galena, that mark the ancient Athenian workings at Laurion.

The mineral now described encrusts the cavities of an extremely vitreous slag, enclosing fragments of wood-charcoal and impregnated with crystals of laurionite with a little friedlerite and matlockite (all three oxichlorides of lead); it appears to be the latest-crystallized of all the associated minerals, and occurs in white or brownish-yellow orthorhombic crystals simulating hexagonal prisms, which have a resinous lustre, a specific gravity of 7·1, and a hardness estimated at 3·5. Insoluble in cold water, they dissolve in cold nitric acid; they appear to suffer no loss when heated at a temperature of about 300 degrees Fahr., but melt readily in the closed tube yielding a sublimate of chloride of lead. Analysis shows the composition of the mineral to be as follows:—Arsenic pentoxide, 12·49 per cent.; lead-monoxide, 38·86; metallic lead, 36·38; and chlorine, 12·47. This result corresponds very closely with the proportions calculated for the formula: $Pb_3 (AsO_4)_2 \cdot 3\ Pb\ Cl_2$. Prof. Lacroix gives the name georgiadesite to the new mineral, in honour of Mr. Georgiades, manager of the Laurion mines. It is the first arsenical mineral found under such conditions as those above described. The arsenic certainly originates from mispickel, which is known to occur at Laurion and may have been accidentally mixed with the galena treated by the ancients. The exceptionally chloridic medium (? the sea-water) in which the slags were disintegrated, enables the mineralogist to understand how a mineral much richer in chlorine than mimetesite has been formed. The chemical difference between georgiadesite and mimetesite consists mainly therein, that the relative proportions of arseniate and chloride are the reverse in one, of what they are in the other, mineral.

It may prove interesting to ascertain whether georgiadesite does not occur among the metalliferous ore-deposits of Chile, say among those of the Sierra Gorda, where plumbichloridic minerals, as yet imperfectly investigated, abound. L. L. B.

JÁNOSITE IDENTIFIED WITH COPIAPITE.

Über den Jánosit. *By* Zoltán von Toborffy. *Földtani Közlöny*, 1907, *vol. xxxvii., pages* 173-180.

The new mineral jánosite was described to the Hungarian Geological Society by Dr. Hugo Böckh in the early days of 1905, as a natural hydrated ferrisulphate, of greenish-yellow colour, belonging to the rhombic system, and corresponding to the chemical formula $Fe_2 (SO_4)_3 + 9 H_2O$. But comparison with two already-known natural sulphates of iron, quenstedtite and coquimbite, shows this formula to correspond exactly with that representing the second of these two minerals, and to approximate very closely to that representing the first. Curiously enough, moreover, it does not seem to have occurred to Dr. Böckh, or to his colleague, Dr. Koloman Emszt, to make comparisons with a third natural sulphate of iron, copiapite, which so closely resembles jánosite, that one may well be confounded with the other. Indeed, Dr. Ernst Weinschenk lost no time in publishing a paper which claimed that the two minerals are one and the same (*Földtani Közlöny*, 1906, vol. xxxvi.). To which Dr. Böckh and Dr. Emszt replied in the same periodical that jánosite, when exposed to the atmosphere, was converted into copiapite, and adduced fresh analyses in support of their contention. Dr. Weinschenk rejoined in a second paper, marshalling a new array of reasons against the putative mineral-species, and Dr. Böckh and Dr. Emszt, in a third memoir, closed the controversy to their own satisfaction with the declaration that, despite all the objections advanced, they upheld the independent existence of jánosite. Regarding this, however, as but a lame and impotent conclusion, Dr. Z. von Toborffy, confining himself strictly to the data furnished by the authors themselves, supplemented by the facts recorded in the literature of copiapite and observations of his own made on Chilian material, seeks to establish the identity of jánosite with copiapite. So far as physical properties go, he tabulates only those data which are the result of microscopic investigation, as comparisons cannot fairly be drawn between results achieved by different methods. The table shows that the crystallographic and optical characters of jánosite coincide in every particular with those of copiapite. The difficulties of chemical investigation are enhanced by the fact that all these natural sulphates of iron are decomposition-products and generally far from homogeneous: the two tables of chemical analyses (coquimbite and copiapite) made by various authors, and shown side by side by Dr. Z. von Toborffy, embody results so divergent as to indicate the impossibility of writing an unchangeable chemical formula for those minerals. Hence the attempted separation of jánosite from copiapite on the ground of chemical composition lacks any solid foundation.

The plea that the former is converted into the latter by the action of the atmosphere is curious, when one considers that in ordinary mine-workings the conditions are far more favourable for such a conversion, long before the jánosite can reach the laboratory or museum where the postulated conversion takes place. L. L. B.

GOLD-MINING IN THE FICHTELGEBIRGE, GERMANY.

Die Goldgewinnung im Fichtelgebirge. *By* ALBERT SCHMIDT. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussischen Staate*, 1907, *vol. lv., pages* 449-458, *with a map in the text.*

Although this is not a very extensive mountainous district, it was for well nigh six centuries famous for its gold-placers and gold-mines. In the nineteenth century the last-remaining traces of the gold-washeries were to be observed along the Zoppatenbach, and in the basin of the Upper Main along the Brandholz valley and the Goldmühl valley near Gold-Kronach. Following the valleys up to their heads, the ancient miners ultimately came upon the auriferous quartz-lodes themselves. These lodes at the Acherwiese, near Schönbrunn, occurred in silicified limestones, and such minerals as cassiterite, galena, titanite, dark or greenish garnet (topazolite), etc., were associated with them. But the lodes worked near Gold-Kronach, among the Cambrian slates, were of far greater importance, and the remains of numerous adits and big heapsteads attest the former activity of the mineral-industry in that area. Antimony-ores were perhaps the chief associates of the auriferous quartz, but gold-and-silver bearing pyrite was present in considerable quantity, as also arsenical pyrite. The author sketches briefly the history of mining in the district here described, from 1220 A.D. until its final abandonment in 1861. After undergoing many vicissitudes, and passing from the possession of one princeling to another, the district was assigned to the kingdom of Bavaria in 1810. The Bavarian Government restricted mining operations at first to the antimony-ores; but, in the decade beginning with 1850, it devoted more attention to the gold- and silver-occurrences, and also to such metalliferous ores as contained noticeable percentages of gold and silver. As late as 1856 new buildings had been erected, including a large smelter where gold was to be extracted by the amalgamation-process; and yet five years later the whole enterprize was abandoned, and buildings and plant were sold for a mere song.

In 1900 the Congress of German geologists visited the site of this abandoned industry, and the opinion was widely expressed that the hopes of a revival were by no means chimerical. Modern methods and modern machinery are factors which may alter what seemed formerly an unprofitable proposition into a good paying concern. In fact, at the very moment when the author was sending this memoir to press, a syndicate had started re-opening some of the old mines. Auriferous antimony-ores are undoubtedly still to be got, and it is possible that Gold-Kronach will be once again the scene of an industrial prosperity as great as that which it enjoyed in the Middle Ages under the rule of the Hohenzollerns. L. L. B.

PHOSPHATE-MINING IN BELGIUM.

Mittheilungen über den Phosphatbergbau Belgiens. *By* TIETZE. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussischen Staate*, 1908, *vol. lvi., pages* 485-502, *and* 13 *figures in the text.*

So far the mining of phosphates in Belgium has been confined to the provinces of Liége and Hainault; but there is reason to believe that the deposits worked in the former province will be ultimately found to extend westwards below the entire countryside of Hesbaye as far as the Dyle (in the province of Southern Brabant). A bibliographical list, consisting of twenty-three entries, is appended to the introductory portion of the memoir.

Beginning with the district of Hesbaye in the province of Liége, it is to be observed that the phosphate-deposits are intercalated among the Upper Cretaceous strata: they lie between the Maastrichtian stage (with which their genetic association appears to be most intimate) and the uppermost Senonian, the Chalk of Spiennes. The section universally exposed in the phosphate-mines is, in descending order, as follows:—Loam, with rolled pebbles at the base; sand; flint-band; phosphate-band; and Chalk. The loam (*Limon hesbayen*) varies in thickness from 5 to 23 feet; it contains 70 per cent. of pure silica and sufficient alumina to render it available for brick-making. This loam lies, to all intents and purposes, conformably upon fine-grained white and yellow sands, from 26 to 33 feet thick, which exhibit no distinct bedding: they are supposed to be of Oligocene age. Below these comes a thick band of great, angular, closely-packed blocks of flint, attaining a maximum thickness of 23 feet: this forms so compact a mass that holing can be carried on underneath it, without the slightest fear of its breaking down. Towards their base the sand-and-clay pockets which extend from its surface downwards into the flint-bed contain a certain amount of phosphatic limestone, sometimes as much as 24 per cent. There is a gradual diminution in the size of the flint-blocks and a corresponding increase of the interstitial material (sand and clay) downwards, until finally the phosphate-deposit proper is reached. The junction between this and the flint-band is nevertheless sharply marked. In the phosphate-bed two layers are generally distinguishable: (1) the upper, poorer in phosphate and richer in iron, contains the phosphatic material in the form of grains and rounded nodules embedded in a greyish-yellow clayey mass. These originally angular nodules are covered with a brown patina, though pale-yellow in section, and are so soft that they can be scratched with the finger-nail. The thickness of this upper layer ranges from an inch or so to 20 inches; (2) the lower and richer layer is less conspicuously nodular, with a frequent tendency to assume a banded structure. The bands, whitish to grey, course parallel with the surface of the underlying Chalk, which, so far from being a horizontal plane, is extremely irregular, with many small hillocks and depressions in it. It is hardly necessary to add that this irregularity not only constitutes a disadvantage in mining the phosphate, but may in places give rise to false estimates of the value of the deposit, if the preliminary boring happens to have hit the thickest or deepest portion of it. The general or average thickness of this bottom-layer is only a matter of a few inches, and the entire thickness of the workable phosphate-bed (both layers included) usually ranges from 16 to 20 inches. A few analyses of Liége phosphate are tabulated, showing percentages of phosphorus pentoxide varying from 22·13 to 27·2 and 33·1. It is assumed either that the phosphate-bed and flint-band of the Hesbaye district are in part the residues of the solution by surface-waters of the Maastrichtian Chalk and in part of the solution of the Upper Senonian Chalk below it; or that they are really derived from a Chalk horizon intermediate between those two.

The phosphates legally belong to the landowner, and, if he is unwilling to work them himself, he sells the right to do so at a price per acre or per cubic foot. The usual method of working is to sink small, circular shafts without tubbing: beginning at one side of a concession, say, with two rows of five shafts, the distance between each row being 100 feet, and between each shaft 65½ feet; when the phosphate-bed is reached the several shafts in each row are joined by a bottom-level, and generally from one end of each row a cross-cut is driven to join up the two bottom-levels. As the material is so soft, it is mined with a short-handled pick and, after a preliminary rough

sorting of the poorer stuff from the richer, shovelled into skeps or kibbles. Above bank, women subject the stuff to a second, more careful sorting; they are exposed, winter and summer alike, to all the vagaries of wind and weather, as costs have to be kept so low that the management cannot afford to build shelters. There is no trouble with water below ground, and scarcely any timbering is used; the men get down to their work by means of slings attached to the haulage-ropes in the shafts. As the phosphate-deposit is of inconsiderable thickness, its working does not affect the surface injuriously, and the landowners' agricultural pursuits suffer but little interference. It takes about three months to work out an area 328 feet long and 20 feet broad: then, alongside this, a fresh area is opened up, and so on. Wages are paid on the piecework system, averaging for men 4s. 2d. *per diem*; for overseers, 4s. 7d.; and for women-sorters, 1s. 5½d. The ton of phosphate, containing, as it comes from the mine, 20 per cent. of moisture, is reckoned to cost 1s. 1d. to 1s. 2d. delivered at the works; but interest on capital and amortization are not included in this cost-price: Precautionary regulations are enforced in the mines, by decree of the Provincial Government enacted in 1891.

The stratigraphical and other local conditions are such that the deposits are not likely to be worked at a lower cost by any other method than that at present in use. The output for the year 1904 exceeded 125,000 metric tons, from about a dozen small mines. The better grade of phosphate, after drying and cleaning, may contain as much as 60 per cent. of tricalcic phosphate, and finds a ready sale. The lower grade, after careful grinding and colouring with a green aniline-dye, is largely sold in Britanny: the Bretons formerly obtained all their phosphate from the Ardennes, and as this had a green coloration, they reject any phosphate that is not green as being a poor fertilizer.

The phosphates of Hainault are chiefly got in the neighbourhood of Mons, and they occur in two forms: (1) the so-called "rich phosphates," which, from the point of view of their origin, possess great analogy with those of Hesbaye; and (2) the phosphatic chalks. They are found near the top of the Cretaceous System, from the lowermost Maastrichtian Stage to the uppermost Chalk of Spiennes; but, in that interval, markedly contrasting with the stratigraphical conditions of Hesbaye, a considerable mass of beds is intercalated, from which the greater part of the Belgian phosphate-output is derived. These beds occur in an incompletely-closed basin (a Coal-measure syncline), the deepest point of which lies exactly below the town of Mons; and, thinning out towards the rim of the basin, they thicken immensely towards its centre, although at the same time the proportion of phosphate therein diminishes considerably. The uppermost Senonian here passed upwards into the Ciply Chalk, wherein three horizons are discernible: the lowest, containing many bands of flint and little phosphatic chalk; the middle, without flints and much richer in phosphate (up to 15 per cent.), and the topmost, with much flint again, but also by far the richest in phosphate. This constitutes essentially the workable phosphatic chalk, with a maximum percentage of 40—but the material has to be submitted to a process of enrichment, in order to make it marketable. Just as in Hesbaye, wherever undecomposed Maastrichtian beds are still preserved, no accumulation of phosphate is seen in the underlying Senonian; and this observation may be extended to the Tertiary *tufeau de Ciply*, for, where this is preserved unaltered, no phosphate occurs beneath it. The north-western extension of the basin towards Baudour was first discovered in 1895.

The phosphatic chalk of Ciply may be regarded as the "mother-rock" of

the rich phosphatic sands. The question of differences in coloration is discussed, in which, of course, the varying degree of oxidation is the main factor, and it is shown that the rich brown phosphates are derived from brown chalk, and the grey phosphates from grey chalk.

The general method of working the rich phosphates may be described as surface-stripping, followed by quarrying. One of the greatest opencast phosphate-workings now in existence was started ten years ago at St. Symphorien. The daily output averages 600 or 650 metric tons of phosphatic chalk; operations are carried on at night under the rays of the electric light. The methods of stripping, quarrying, and washing and preparing the crude phosphate are described in detail. Including every possible item, the prime cost at St. Symphorien of a ton of marketable phosphate works out at 10s. to 11s. 8d.

West of Mons, on the other hand, the tendency is now all towards underground workings. Of such, the Malogne Company's mines near Cuesmes are an example. The bed there worked strikes from west-north-west to east-south-east over a distance of a mile and a half, and dips 8 or 10 degrees northwards and north-eastwards. About 1,100 yards from the western boundary of the concession a shaft is sunk to a depth of 130 feet or so, to the bottom of the phosphate-bed. From this shaft various levels and cross-cuts are driven. A pumping-engine below ground sends the pit-waters up to the surface by means of a small shaft specially sunk for that purpose. Pillars, varying in thickness from 13 to 20 feet, in inverse ratio to the solidity of the roof, are left in the workings, and there is practically no timbering. The heavy damages payable to landowners in case of disturbance of the surface forbid any attempt to work away these pillars, and thus much phosphate naturally goes to waste.

The memoir terminates with a statistical synopsis of the phosphate-production of Belgium from 1873 to 1906, both years inclusive. L. L. B.

MINERAL RESOURCES OF APURIMAC, PERU.

Recursos minerales del Departamento de Apurimac. By A. Jochamowitz. *Boletin del Cuerpo de Ingenieros de Minas del Perú*, 1908, *No.* 58, 99 *pages, with* 13 *figures in the text, and* 1 *map.*

The description given by the author of the journey from Mollendo on the Pacific seaboard to Abancay, the capital of the department of Apurimac, first by railway, then by coach, and finally on horseback, embodies a vivid picture of the difficulties of communication which retard the progress of that portion of Peru. The department is subdivided into five provinces, three of which are dealt with in the memoir under consideration.

Beginning with the province of Antabamba, the author in a few pregnant sentences brings before the reader the utter desolation of its chief town (if indeed a haphazard assemblage of shanties can be called a town), and points out that not one of the inhabitants is engaged in mining operations; yet there are villages in the province where every person possesses a "traditional or hereditary" knowledge of the process of extracting gold from placer-deposits. Well-bedded quartzites exhibiting a saccharoidal fracture and weathering red (owing to the presence of iron) along joint-planes are to be found throughout the province; they are, in places, overlain by blue limestones. A deposit of iron-pyrites occurs in the quartzites of the Cerro Acco, about 4½ miles east of Antabamba town. In various river-gorges the granites which underlie the sedimentary formations are exposed. At some localities thin bands of black slate are intercalated among the quartzites; at some, too,

a quartziferous diorite is seen to burst through the sedimentaries, and these show unmistakable evidence of contact-metamorphism. In the Paranccire gorge in the Sabayno district, metalliferous lodes bearing copper and iron-ores (among them malachite, azurite, and arsenical pyrites), with a ferruginous gossan, are exposed. Among the quartzites of the Utupara ridge, a lode some 20 inches thick occurs, of extremely cavernous brown iron-ores containing in places as much as 2 ounces of gold per metric ton. That these iron-ores are the decomposition-products of pyrite is shown still more clearly along the Rio Piscco, where the original pyrite alternates with bands of the oxidic ore and of crumbled quartzite. Free gold occurs here also among the oxides and among the quartzites of the roof or hanging wall. In the district of Pachaconas, the quartzites are continually traversed by andesitic dykes; the fissures connected with the eruption or intrusion of these undoubtedly favoured the circulation of thermal waters charged with metalliferous particles. The southern flank of the Cerro de Ayahuaya was evidently the site of an active mineral-industry in ancient times, and even now the placers on its northern flank may prove worth working. Water for hydraulicking or other purposes is easily available in the immediate vicinity. In the neighbourhood of the town of Pachaconas itself occurs a certain small auriferous lode among the quartzites containing tin-ores (apparently of very rare occurrence in Peru). The bituminous shales of the district contain so much clay, that they are worthless from the industrial point of view; and the same unfavourable opinion is expressed of a salt-deposit which has been found there.

Passing briefly over much that is of small interest to the mining geologist in the province of Cotabambas, the author describes the gold-placers of the districts of Haquira and Mara. It would not appear that the percentage of the precious metal therein is very high, but big nuggets are occasionally found. In the Huayllati district, the Portuguese, until they evacuated the country in virtue of a Royal decree, actively worked a considerable ore-deposit (traces of copper and iron-ores are still seen); before leaving, they destroyed, as far as possible, all clues to the workings. But these were rediscovered a few years ago by Senhor Rodriguez; he found a great lode, 8 to 10 feet thick, with rhodonite, pyrite, chalcopyrite, and galena, occasionally rich in gold, also a black compact mineral containing as much as 300 ounces of the precious metal per metric ton. The waste-heaps left by the ancient miners could be now worked over at a great profit for the gold that is in them. In the Charca range, a metalliferous lode crops out over a distance exceeding 1,100 yards: it is 10 feet thick, and is filled with oxides of copper and iron, the gangue-mineral being quartz. Some specimens have yielded on assay 15 to 20 per cent. of metallic copper. It was evidently worked in ancient times, but the indications of an important ore-deposit here are in every way so unmistakable, and the probability of gold being found in the still unworked ores is so great, that mining operations conducted on an adequate scale might well prove successful. The Huaquiri placer has been shown to contain about 255 grains of gold for every ton of material worked over. Recent attempts to rework it have been abandoned, apparently because the gold occurs in flakelets which are too easily swept away by water. On the left bank of the Yerbahuma river-gorge, in the district of Chuquibambilla, a great ferruginous *creston* or dyke runs from top to bottom of the gorge: it occurs among grey saccharoidal limestones near the junction with the eruptive diorites, which hereabouts form practically a mountain-range, and is really a metalliferous lode, about 10 feet thick. This lode, as well as those of Antacancha and Yuringa, in the same district, was in former times the object of an active mineral-industry. Be-

fore making any attempt to forecast the possibility of reviving this industry, some expenditure would have to be incurred in re-opening the old workings, now obstructed by falls of rock, etc. The Tapairiqua placers are described; they are worked by the aboriginal natives in the most primitive fashion.

During the period of the Spanish domination, it was to its mineral-industry that the department of Apurimac owed its prosperity. It is only within recent times that agriculture, cattle-breeding, etc., have assumed any importance there. It would appear that the mines were chiefly worked by Portuguese, and that the workings were on a considerable scale may be gauged from the number of fallen-in adits, etc., scattered over the country These old workings have been so long abandoned that many have been quite forgotten; and there is at the present day only one mining syndicate at work in Apurimac. L. L. B.

KÖNIG AND GÜTZLAFF COAL-WEDGING MACHINE.

Ein neuer Keilapparat und die mit ihm erzielten Versuchergebnisse. ANON. *Glückauf*, 1907, *vol. xliii., pages* 1429-1432, *with 6 figures in the text.*

Experiments have been conducted at the Reden colliery, near Saarbrücken, with a König and Gützlaff coal-wedging machine. Within a quadripartite, internally conical shell moves a left-handed three-threaded screw, loosely attached to the four parts of the shell or wedge, and held firm by a nut. The dome-support, forming a loose bearing for the screw, is, in order to lessen friction, provided with ball-bearings. The quadripartite, externally cylindrical shell or wedge, bears at definite intervals on its outer surface denti-form ribs, the function of which is to prevent back-slipping as they fix themselves in the sides of the bore-hole; at the outer end of the cylindrical shell or wedge, is a funnel-shaped attachment which receives the balls.

The screw is so connected with the shaft which sets it in motion, that it can be used in conjunction with any form of drilling apparatus. The wedging-machine is introduced into a drill-hole of, say, 4 inches diameter in such a manner that the funnel-shaped attachment remains vertical. Then the smallest lot of balls (three, each 1 inch in diameter) is placed in the funnel, and the machine by turning to the right is set in motion. At it turns round, the balls revolve around their axes, and if they reach the end of the cylindrical shell or wedge without having effected sufficient results, a few twists of the screw brings them out again, and a set of balls of larger diameter is placed in the funnel.

At certain points in the eastern district of the Reben colliery, in the workings of the Kallenberg seam, shot-firing had been peremptorily stopped on account of the evolution of considerable volumes of fire-damp, and thus recourse was necessarily had to wedging. The seam consists really of two layers of coal, 36 inches and 30 inches thick respectively, between which there is a band of barely 2 inches. The roof is a hard shale, and the floor consists of a coaly shale, underlain by a middling hard shale, and that again by a hard shale. The dip averages 15 degrees. The coal is extraordinarily tough, without visible bedding, and in places quartzose.

With ordinary wedging, the coal came down very small, and the strain on the endurance of the work-people was excessive. On the introduction of the above-mentioned machine, however, the work went on much faster, and the physical strain, so far as the workpeople were concerned, was very much lessened. The gradual manner in which the machine works prevents the coal from crumbling into small, and as a rule one man is sufficient to work it, two being only required at exceptionally difficult points.

For the drilling of the holes, a drill has been used with a twisting motion, with a forward and backward cut, in connexion with a Leyendecker hand-drilling apparatus. This makes a perfectly straight and smooth-sided drill-hole. Statistics comparing the results attained with shot-firing, hand-wedging, and machine-wedging are given: they show that the machine-wedging is from every point of view an improvement on hand-wedging, although, of course, it cannot compare in cheapness with shot-firing. But then the many risks avoided by the disuse of shot-firing must be taken into account, and the wedging-machine compares favourably with others in simplicity and solidity of design, facility of handling, and the small cost of repairs.

L. L. B.

SAFETY-FUZES IN FRANCE.

Extrait d'Une Enquête sur les Mèches de Sûreté. Official. *Annales des Mines*, 1907, *series* 10, *vol. xi.*, *pages* 252-263.

This paper embodies in a condensed form the facts ascertained in the course of an enquiry, instituted by the French Ministry of Public Works, into the utilization of safety-fuzes, on account of certain accidents which had been attributed to over-rapid combustion of these fuzes.

All the fuzes employed in French mines are of home-manufacture, the annual output of the four factories in France where they are made averaging 30,610,000 yards (in rolls of about 11 yards or 10 metres). Rather more than two-thirds of this quantity is used up in the mother-country, the rest finding its way to Algeria and the French colonies.

Whatever their source, the fuzes may be ranged under various categories which have considerable mutual analogy, whether manufactured in France or in other countries. The method of manufacture, with the exception of some trifling details, seems to be much the same everywhere. The exterior envelope, in regard to the combination of the materials of which it consists, appears to admit of considerable variation: but the envelope, however it is made, seems to have no effect whatever on the rapidity of propagation of ignition.

This rapidity of propagation may vary with the chemical composition, the granular texture, and the hygrometric condition of the gunpowder in the fuze. It may also vary according to whether the fuze is freshly made or stale, or according to whether the latter has been kept in a dry place or a damp one, in a cool atmosphere or a heated one. It has been shown by the experiments that this variation may range in time, for fuzes burning in the open air, between 40 and 150 seconds. The general average, corresponding to the conditions obtaining on the whole in mining practice, would appear to be about 100 seconds in the open air, both for French fuzes and for those from other countries which were subjected to identical tests.

Mr. Loiret compared two fuzes, first after they had been stored in a very dry place, and then after they had been exposed for a long time in a very damp part of the mine: he got for one of them 85 seconds and 100 seconds (or a reduction of 17 per cent.); and for the other 109 seconds and 150 seconds (or a reduction of 45 per cent.). Mr. Aron, by warming fuzes in the sunlight or in a stove, got variations amounting to a maximum of 30 per cent. He found also, that if a fuze be burnt in the open air and strongly pressed under foot or squeezed in a vice, a loud explosion takes place when the ignition reaches the compressed portion, and generally too when the ignition leaves the compressed portion to travel farther on. Mr. Aron, assuming that ener-

getic compression of the fuze might induce acceleration of the speed of ignition, placed a fuze within an iron-tube (closed at one end by an iron slide, *bride*), and well stemmed with plastic material. He obtained in this way speed-accelerations of 500 per cent., or say a speed of at least 19 seconds per yard. These experiments were repeated in the live rock, under ordinary conditions of working, and with appropriate stemming speed-accelerations amounting to as much as 296 per cent. were obtained. The experiments made by Mr. Champy, assistant-general-manager of the Anzin Colliery Company, in the main confirmed Mr. Aron's results. Whence one may conclude that there is a very general similarity between all the fuzes obtainable in commerce, in regard to their speed of ignition; but the possibility of considerable variations in the normal speed of a given fuze is not excluded, owing to the intervention of such factors as its intrinsic character, its actual state at the time of use and the manner in which it is used, and especially the conditions and mode of stemming.

The defects to which attention is directed are of three kinds: (1) Defects involving too great a speed of propagation, and consequently premature explosions which might prove particularly dangerous; (2) defects occasioning too slow a speed of propagation or else miss-fires, with results to be described rather as vexatious than as dangerous; and (3) defects causing lateral spurting. Notwithstanding the recent great fall in price (nearly 50 per cent.) of fuzes, the investigation has shown that the defects enumerated above are no more frequent now than at any previous time; nor are the fuzes of one manufacturer, on the whole, more open to criticism than those turned out by another.

Lateral spurting is declared to be a matter of interest and importance in the case of fiery mines alone. To what extent it is dangerous even there, is a question that can only be settled by direct experiment.

Passing over the defects which occasion miss-fires—and most factories are so equipped as to discover these by manual or by mechanical means—the report deals with the defects which, by exaggerating the speed of ignition, may cause premature explosion. It will be noted, however, that it has, in no case where an accident was really or supposedly assignable to this cause, been possible to establish beyond doubt that there was an actual defect in the make of the fuze. Subsequent experiments on the very same roll of fuze have only shown it to possess the normal speed of ignition. Whence it may be inferred that such accidents are more justly assignable to the conditions under which the fuze is employed: it has already been pointed out that these conditions, from those concerning the state of preservation of the fuze, to those concerning the stemming or the particular length employed, may involve variations, even in a quite normal fuze, sufficient to account for the most unpleasant surprises in the nature of premature explosions. Lengthening of the fuze might diminish the risk; but there is always a risk inherent in the use of any fuze, despite the immense progress which it has involved in the comparative convenience and security with which explosives may be handled.

At the Anzin collieries, about 0·5 per cent. of every delivery of fuze is tested in the dark (to ascertain whether there is lateral spurting). Fuzes of too low or too high a speed, or which do not ignite with sufficient regularity, are left on the maker's hands. Various collieries in the Pas de Calais and in other parts of France also test the fuzes on delivery.

The Committee of Enquiry was unanimously of opinion that such tests should be made obligatory by ministerial decree, but appears to have been somewhat divided as to the particular formulæ that should be set up as standards.

L. L. B.

SURFACE AND UNDERGROUND SUBSIDENCE IN COAL-MINING.

Von dem Niedergehen des Gebirges beim Kohlenbergbau und den damit zusammenhängenden Boden- und Gebäudesenkungen. *By* R. Hausse. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussischen Staate*, 1907, *vol. lv., pages* 324-446, *with* 63 *figures in the text and* 3 *plates.*

It is not possible to give more than a very brief summary of the contents of this thoroughly exhaustive memoir. In the first section, the causes which condition the subsidence of the covering strata into the cavities left by underground working are dealt with generally. The second section describes the manner in which this subsidence takes place, whether through fracture or through bending of the "cover." Fracture is described under the categories "median" and "lateral," and the importance which attaches in each case to its direction is emphasized. In the third section are considered the subsidences of soil and buildings, due to the extension of the effects of the phenomena up to the very surface. The question of "safety-pillars" is adequately discussed in the fourth section; and in the fifth it is pointed out that the magnitude of surface-subsidence depends not only on the height of the underground excavations, but also on the methods of working and on the nature of the rocks. The last-named factor must also be taken into account in estimating the probable duration of the subsidence of a given area. The ten pages of the sixth section are devoted to the consideration of the means to be applied, both above and below bank, with the view of obviating damage to buildings; and also to the prevention of the inflow of water. Below bank, of course, the leaving of sufficiently large pillars of coal is stated to be the surest palliative against subsidence; above bank, the precautions to be taken by the architect, in designing the structure of buildings on an area which may possibly be affected by subsidence, are carefully set forth in detail.

In the second part (or seventh section) of the memoir, the author considers the results of subsidence of soft shaly strata of a plastic nature as a consequence of underground working; in the third part he deals with subsidences due either to desiccation or tapping of water-bearing strata, or to slip or creep of saturated clays, or finally to the leaching-out of the soluble particles which are among the constituents of certain strata; and in the fourth part (or ninth section) he enumerates the possible causes of damage to buildings, and says a few words as to the methods of estimating damage caused by subsidence. L. L. B.

UNWATERING OF STRATA AND SUBSIDENCES IN THE RHENISH-WESTPHALIAN COAL-FIELD.

Zur Frage der Entwässerung lockerer Gebirgsschichten als Ursache von Bodensenkungen, besonders im rheinisch-westfälischen Steinkohlenbezirk. *By* R. Bärtling. *Zeitschrift für praktische Geologie*, 1907, *vol. xv., pages* 148-153, *with* 2 *figures in the text.*

The author briefly reviews the recent literature of the subject in Germany, and sets himself especially to combat the opinions advanced by Mr. F. Trippe, who, in an article published in *Glückauf*, in May, 1906, laid down that depression of the underground water-level would alone suffice to cause subsidence at the surface. He claimed that the hydrostatic pressure of the underground water initiates a disintegration of such loose deposits as gravel, sand, or loam, and on release of this pressure subsidence at the surface naturally follows. But, not to speak of the weighty theoretical objections to Mr.

Trippe's views, the experiments conducted by Messrs. A. Herzberg and J. Græff have shown them to be untenable.

In considering the phenomena connected with underground water, other factors besides the natural laws of hydraulics come into play, not the least among them being the action of capillarity. Nor can the underground water-level be properly likened in every particular to a system of communicating pipes, as it is very far from forming a horizontal plane. Owing to its variability in altitude, hydrostatic pressure is set up, and results in a gradual uninterrupted flow of the underground water, from the shallow areas to the deeper-lying areas, through the pores of the solid rocks and through the interstices of the more loosely-built deposits; but the friction to which the water is subjected in making its way through these loose deposits inevitably diminishes the effect of the initial hydrostatic pressure.

All the loose deposits which cover the surface in the Rhenish-Westphalian coal-field are of aqueous origin, or at all events were laid down with the co-operation of aqueous agencies, with the single exception of the Boulder-clay. The gravels and sands were deposited by the waters arising from the thawing of the Glacial ice-cap, or were piled up in the present river-valleys together with fluviatile loam, at a time when those valleys had not been cut down so far as they are now. From the day when the waters reached the summit of the Haarstrang (as, for example, at Friedrich Wilhelmshöhe, south of Unna, 700 feet above sea-level) leaving the Ruhr rubble on its top, and laying down river-loam at almost the same altitude, the underground water-level has been gradually sinking to its present depth.

The author appears to scout the idea that a real diminution of volume takes place in loose-textured deposits through the withdrawal of water, unless solid particles are simultaneously carried off with the water; in that case, subsidence of the surface does follow on the deepening of the underground water-level. He cites, in contradistinction to Mr. Trippe, the very example selected by the latter. A coal-seam, dipping southwards, had been worked out at Dorsten, on the southern bank of the Rossbach. Subsidences soon became apparent on the northern bank, stretching away in the opposite direction, and these sunken areas were soon flooded by water. The working-out of the coal-seam had evidently caused the numerous fissures in the Chalk-Marl overlying the Coal-measures to widen out: the water escaping through them carried with it some of the quicksand (of which the presence has been proved); and the extent of the subsidence can be shown to depend on the amount of quicksand thus carried off. Similarly, it has been observed in the Upper Silesian coal-field that funnel-shaped depressions occur in places in worked-out districts where quicksand has been carried off.

Subsidences occasioned by the withdrawal of material from deposits by outflowing water are not, of course, confined to mining districts, and examples are cited from the country along the Lower Rhine which are very similar to the subsidences brought about by mining operations.

In conclusion, the author emphasizes his assertion that the hydrostatic pressure of underground water cannot bring about disintegration of loosely-built water-bearing deposits. Consequently, a diminution in volume of these deposits, following on diminution of that hydrostatic pressure, is inconceivable, and subsidence is essentially conditioned by the withdrawal of solid material. L. L. B.

ELECTRIC SAFETY-LAMP EXPERIMENTS AT CAMPHAUSEN, GERMANY.

Versuche mit tragbaren elektrischen Grubensicherheitslampen auf der Grube Camphausen der Königlichen Berginspektion XI zu Camphausen. By — Rossenbeck. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussischen Staate*, 1907, *vol. lv., Abhandlungen, pages* 269-282, *with* 9 *figures in the text.*

The management of the fiery mines of Camphausen and Brefeld follows with keen interest the development of every novelty in the matter of rescue-apparatus, and no pains are spared to equip these mines with the most recent appliances. Among these, portable electric safety-lamps naturally find a place; and for the last ten years (that is, since 1897), a series of exhaustive tests have been carried out, with the view of determining the reliability and duration of various types of such lamps. The principal requirements attaching to their use are summarized as follows:—With the greatest possible brilliancy and duration of light the ideal lamp must combine the least possible weight. Its size and circumference must be such as to permit of easy handling, wherefore projections and sharp angles are to be (as far as practicable) avoided. The switch-arrangement must so work that there is no possibility of ignition in gaseous mixtures by means of an initial or terminal spark, a consideration to be also borne in mind when it becomes necessary to screw on a fresh incandescent globe. The entire structure of the lamp must be such as to enable it to withstand unalterably the rough usage to which it will be infallibly subjected in the course of everyday work down the pit.

The tests were not, however, directed to the choice of a lamp suitable for general use by the pitmen, but to that of a lamp for working in an atmosphere of combustible or unbreathable gases, fire-damp, after-damp, and so forth. In fiery mines the general use of the electric lamp is at present to be deprecated, not only on economic grounds, but also because it fails to indicate the presence of fire-damp. The author has no knowledge of any fire-damp indicator, of dimensions small enough to permit of its being attached to an electric safety-lamp, and to be at the same time capable of clearly and unmistakably revealing the presence even of minute quantities of pit-gas.

The first experiments were carried out with a couple of Richter lamps, the structure of which is figured and described. They took 12 hours to charge, and burnt thereafter continuously for 8 hours. It was found that a lamp might be allowed to stand for as many as 8 days after charging without the duration of illumination being thereby affected; but, for any period beyond that, a marked decrease in duration was observed, becoming more marked as the interval between charging and use was extended. The lamps were tested in conjunction with the pneumatophore, and in fine proved unreliable and unsuitable for use in the pit. Meanwhile, the firm which had furnished them had brought out another lamp, designated as "Pattern 98" (*Modell 98*), which differed from the old Richter lamp in the arrangement of the accumulators and the incandescent globes; it was also of smaller dimensions and lighter to carry, and special care had been taken to secure easy interchangeability of parts. With less brilliancy of light, it burnt longer (12 hours' guaranteed duration): it proved easy to handle, but in the further course of the experiments, acids and acidic vapours escaped from the cells of the accumulator, oxidizing or encrusting the switch and other metallic parts. This rendered it impossible to keep the lamps always in a fit state for use. Accordingly the same firm brought out their "Pattern 99" lamp, with dry accumulators, weighing about

6 lbs., and guaranteed to burn for 10 to 15 hours at a tension of 4¼ to 4½ volts. This lamp proved to be the best of any placed on the market up to the year 1899, and an order was placed for six to be used in the Camphausen rescue-stores; but evidences of deterioration in duration of light and tension became perceptible after storage for a year or two. Moreover, in the course of the drilling of rescue-classes, setting up dams against fires, and similar operations, the lamps had proved very unequal in their capabilities: some burnt well, giving every satisfaction, while others would not burn at all.

Trials were next made with the Adolf-Bohres lamp, shown at the Düsseldorf Exhibition (1903). Provided with a magnetic lock, this lamp differs essentially in form from the earlier quadrangular types, and resembles rather the benzine safety-lamp. Ready for use, it weighs just 3¾ lbs. It is inferior in brilliancy to the Richter lamps, but its duration is much the same (9½ to 10 hours). At Camphausen tests were made with the pattern in which the incandescent globe is placed above the cylinder containing the accumulator. The illuminating film or thread is made of osmium, the use of which is regarded by the author as an enormous advance in electrotechnics, more particularly as a tension of 2 volts is sufficient to make it incandescent, and consequently a single-cell accumulator may be used. Moreover, the osmium-film withstands vibration much better than the ordinary carbonized film, and whereas the latter will burn for at most 100 to 120 hours, the osmium will last for 300 to 500 hours. The latter yields a dazzling white light of undiminishing brilliancy, as there is hardly any perceptible disintegration of the osmium and no blackening of the lamp-globe. Theoretically, this should have been a perfect lamp; but trouble ensued, on account of the escape of acids from the accumulator. Certain improvements were then made, and two lamps were kept in use for two months after which short-circuiting became very noticeable. Further improvements were thereupon made, and five tests were carried out with very satisfactory results.

Experiments conducted with the Catrice lamp led to its ultimate rejection, as was also the case with the "Phänom" lamp (Schneider patent).

In 1904 the Gülcher lamp was placed before the Camphausen management: it is figured and described at length. It is of cylindrical shape, and the incandescent globe is carried above the cylinder which contains the accumulator. The film is of osmium, and the total weight of the lamp is 5½ lbs. (There is a spiral fire-damp indicator consisting of a salt of platiunm.) Some slight defects in the construction, which were revealed in the course of experiment, were easily remedied by the manufacturer, and the results of exhaustive tests proved so satisfactory that five lamps were ordered for the Camphausen rescue-stores (in addition to the three already in use), and eight for the Brefeld colliery.

On the whole, as regards reliability, duration of light, and security in handling, the Bohres and Gülcher lamps proved the best of any. The Bohres lamp is somewhat lighter than the other, but takes twice as long to charge. Both are equally easy to handle. Still, the preference must be given to the Gülcher lamp, as it can be recharged so much more quickly after use.

Rescue-appliances in general are, however, much in advance of electric safety-lamps in regard to reliability. So long as the lamps are based on the use of so delicate and easily disturbed an apparatus as an accumulator, so long will it prove impracticable to turn out a lamp which can answer every requirement for an indefinite time. L. L. B.

A NEW FRENCH GLASS FOR SAFETY-LAMPS.

Sur les Nouveaux Verres de Lampes de Mines des Cristalleries de Baccarat. By G. Chesneau. *Annales des Mines*, 1908, *series* 10, *vol. xiii.*, *pages* 435-439.

In this official report, presented to the permanent Commission for Scientific Researches as to Fire-damp and Explosives used in Mines, the results are announced of the experiments carried out with a new variety of glass, submitted to the Commission by the Baccarat glass-works. These experiments were conducted on the same lines as the tests to which the Jena glass manufactured by the firm of Schott had been previously subjected. They included (1) tests by immersion in water; the samples of glass, having been heated up to 212° Fahr. by prolonged submergence in water slowly brought up to boiling point, are seized by wooden nippers and immediately plunged into a large recipient containing cold water (temperature = about 60° Fahr.); (2) the rapid-heating test, wherein the normally cold glass is placed exactly above the central axis of an annular Berzelius gas-burner, 45 millimetres (1·8 inches) in diameter.

It has already been shown that the extraordinary resistance of Jena glass to breakage by heating is due to a chemical composition so calculated as to secure a very small co-efficient of expansion: that is, the glass is a feebly alkaline silico-borate of soda, with extremely minute quantities of lead and zinc.

It was along altogether different lines that research was directed in the case of the Baccarat glass-works: here, it was sought so to increase the elasticity of the glass as to enable it to resist successfully the action of rapid heating and cooling; and this result was achieved by the addition of increasing quantities of magnesia and oxide of zinc to an ordinary lead-glass. The standard composition of such a glass is tabulated as follows: Sand, 75 parts; bicarbonate of soda, 13; carbonate of magnesia, 9; oxide of zinc, 6; and red lead, 50 parts. Lamp-glasses were tested of the usual dimensions: that is, 60 millimetres (2·4 inches) in height, the same in external diameter, and from 5 to 6 millimetres (0·2 to 0·24 inch) in thickness. Out of ten samples tested by immersion in cold water, none was fractured. No less than twenty samples were tested over the Berzelius gas-burner, and after 5 minutes' heating not one was cracked. All the samples were subsequently laid out to cool upon a wooden plank, and on examination several weeks later they were still found uncracked.

This new Baccarat glass is of a slightly yellowish tinge, like the Jena glass previously tested by the Commission; but this coloration does not appear to diminish the illuminating power of the lamps in which such a glass is used.

L. L. B.

THE MÜLLER SAFETY-LAMP.

Sur la Lampe de Sûreté Müller. By G. Chesneau. *Annales des Mines*, 1908, *series* 10, *vol. xiii.*, *pages* 440-449, *and* 1 *figure in the text.*

This lamp, devised by Herr Otto Max Müller, of the Consolidation collieries, at Gelsenkirchen, in Westphalia, has been tested by the French Permanent Commission on Fire-damp and Explosions with favourable results.

It is a petrol- or spirit-lamp with circular wick, double screen, admission of air from below, magnetic lock as in the Wolff lamp, and paraffined igniter. But it differs from the Wolff and other lamps already authorized for use in France and Belgium in several particulars. One of its chief characteristics is, that, once the lamp is opened, the wick is automatically shut down by a

metallic hood which frustrates any attempt to relight it. Lighting can only be effected by means of the igniter which is secured by the magnetic lock, the consequences being (1) increase of security because of the automatic extinction of the flame so soon as the bolt that closes the lock is drawn; (2) almost complete suppression of any vaporization of petrol or spirit from the wick, entailing considerable economy in consumption and a notable diminution of inflammable vapours in the atmosphere of the lamp-room.

The mechanism by which this is secured is explained and illustrated. The tests were carried out in explosive mixtures of atmospheric air and illuminating gas circulating at a considerable speed, and the lamp behaved at least as well as any of the best lamps which had been previously tested by the Commission. Its use has been officially authorized in fiery mines in French territory. L. L. B.

DUST-EXPLOSION AT THE GARDANNE MINE, FRANCE.

Note sur une Explosion de Poussières survenue à la Mine de Gardanne le 9 janvier, 1907. *By* — RIGAUDIAS. *Annales des Mines*, 1908, *series* 10, *vol. xiii.*, *pages* 379-396 *and* 2 *plates.*

About noon on January 9th, 1907, an explosion took place in the lignite-mine of Gardanne, in the department of the Bouches du Rhône (Provence), whereby four persons sustained mortal injury, and eight others were incapacitated for many weeks. In contrast with its disastrous effect as far as injury to life and limb was concerned, this dust-explosion caused hardly any damage to the workings that is worth mentioning.

Two seams only, out of all those comprised within the Fuveau lignite-basin, are seriously worked at the Gardanne mine, namely, the Gros Rocher (about 5 feet thick, including partings); and, 165 feet below it, the Grande Mine (6½ to 9 feet thick, including partings). The mineral resembles in character and appearance the meagre long-flame coals. Analyses carried out in 1907 yielded the following percentage results:—Fixed carbon, 48·5; volatile matter (including 8 to 10 per cent. of water), 45·4; and ash, 6·1. Analyses carried out during the same year, of the dust collected from the screening-apparatus, showed the following percentage composition:—Fixed carbon, 35·8; volatile matter, 40·95; moisture, 3·75; and ash, 19·5. The total output of the mine for the year 1906 amounted to 204,500 metric tons. The barren stuff and the débris from the forewinning operations are used for packing; and moreover massive pillars of coal are left in the neighbourhood of the principal haulage-ways and wherever the durability of the roof seems inadequate: these pillars bear a proportion of 20 per cent. to the total surface stripped. The ventilation is natural, and its course is shown on the plan which accompanies the memoir. In the pits of the Fuveau basin evolution of fire-damp is of extremely rare occurrence, and is never of great volume. Such accidents as have been traced to it were of little consequence. There was perhaps some tendency to more frequent evolution of fire-damp in that portion of the Gardanne mine which lies west of the Biver shaft, and certain precautionary regulations were observed in consequence. Although these regulations did not strictly apply to the district lying east of that shaft (where the disaster occurred), daily inspection of the atmosphere in the workings in the Gros-Rocher seam and frequent tests with the Chesneau lamp were carried out. It cannot be said either that the mines of the Fuveau basin are dusty; on the contrary, the hydrological conditions of the district are such as to make the mines very damp, and pumping has at all times bulked largely in the necessary cost of working. The Gardanne

measures are honeycombed with small faults, corresponding more or less to the fissures in the overlying limestones, through which the surface-waters percolate into the workings. Even in its driest districts, the mine is singularly free from dust; it is true, however, that what little dust there may be is highly inflammable. A day or two before the disaster here described, at the screening belts of Castellane-Léonie, near by the Biver shaft, the cloud of dust raised by the simple swinging-over of a coal-tub was ignited by the flame of a naked light. Moreover, experiments conducted at the Liévin station, in the course of 1907, illustrated the high degree of inflammability which characterizes the Fuveau brown-coal dust, showing that it is at the very least as dangerous as the Courrières dust. But the general dampness of the Fuveau mines, and the very small quantity of dust lying about in even the driest places, had diverted attention from the inflammable character of the dust; and naked lights were everywhere in use, except in the western district of the Gardanne mine (recognized as subject to incursions of fire-damp). Nor was there any restriction, based on the presence or characteristics of brown-coal dust, as to the permissible explosives: grisounite, brick-powder, cheddite, and even dynamite were utilized as appeared most suitable, according to the circumstances of the particular district. In all the hundred years during which they had been worked, not a single dust-explosion had been recorded in these mines; and thus it is that, at first, the Gardanne disaster was described as an explosion of fire-damp.

At the date and hour previously mentioned, six shots charged with gelatine-dynamite had been fired, the first four or five igniting much as usual; but a very loud report followed on one of the last two, and a tongue of flame accompanied by intensely black smoke darted through the roadway, inflicting severe burns on the two shot-firers and their assistant. It travelled through several working-places, scorching eight out of the twelve victims of the accident; while the other four succumbed to the deadly effect of the poisonous gases. Yet not a single pit-prop was thrown down, and no fall of rock took place. Three brattice-doors were blown over, and the points at which they were situated practically determine the area within which the effects of the explosion were felt.

The clothing of the victims was not burnt, and not the slightest trace of carbonization was visible on the timbering. The ventilation was but little disturbed. Very little rescue-work had to be done, and all the victims had been brought to bank before 2 p.m., that is, within less than two hours of the explosion. The flame travelled a total distance of 165 yards or so, and the air-blast which followed on it made its effects felt for a distance of some 330 yards from the working-face. Everything was got into working order again the next day.

For shot-firing in the coal, the management give the preference to grisoutine as a rule, as it is a less shattering explosive than Favier No. 1 or gelatine-dynamite, and consequently does not make so much small coal. But it so happened, in this instance, that the stock of grisoutine had given out a couple of days before the disaster, and consequently gelatine-dynamite was substituted for it. Subsequent investigation showed that, of the six shots fired, four failed to fulfil the normal conditions, owing probably to insufficient tamping. The first shots that went off raised a great cloud of dust in the workings, and the later shots ignited this dust. The explosion stopped short where it did, simply because there was not sufficient dust about to "feed" it and carry it onward. All the evidence completely precludes the possibility of fire-damp having played any part in the disaster.

In consequence of this acident, the French General Council of Mines recommended the issue of a prefectoral ordinance prescribing the exclusive use of safety-explosives in the mines of the Fuveau Basin, save certain exceptions expressly provided for. This ordinance was issued on September 14th, 1907, and it limited the permissible amount of explosive (or charge) for each shot to 300 grammes (say 10 or 11 ounces). L. L. B.

COLLIERY-EXPLOSIONS IN PRUSSIA DURING 1907.

Mittheilungen über einige der bemerkenswerthesten Explosionen beim preussischen Steinkohlenbergbau im Jahre 1907. [Official.] *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussischen Staate,* 1908, *vol. lvi., pages* 520-531, *with* 6 *figures in the text and a plate.*

At the Government colliery called Königin Luise, in the mining district of South Gleiwitz, an explosion of combustible gases took place shortly after 10 a.m. on January 22nd, 1907, whereby ten persons suffered injury (with fatal effect in one case). The site of the disaster was haulage-incline No. 14, at the 820-foot level in the workings of the George shaft. Here the Heinitz seam is from 12½ to 13 feet thick, and yields a caking-coal which tends to dustiness. The presence of fire-damp had never, up till the time of the disaster, been observed in the workings, and consequently no pretence was made of carrying into effect the regulations applicable in fiery mines.

The incline, which slopes at an angle of about 7 degrees, had been more or less broken in up to an average height of 23 feet, in consequence of a fire which occurred in October, 1906, and for several months clearing operations (taking away the fallen coal and stone, retimbering, etc.) had been in progress. For the security of those who were engaged in this work, a provisional protective timbering had been built up, to a vertical height of 13 feet or so; and a horizontal brattice had been put in (as an air-split for ventilation-purposes), consisting of two layers of 3-inch balks which were ultimately destined for the permanent timbering of the roadway. Three 8-hour shifts were worked, under the supervision of overmen and deputies. The illuminants used were Wolf benzine safety-lamps and electric portable lamps. The course of the ventilation is described and figured.

During the first few weeks of the clearing operations the masses of fallen coal and bituminous shale in incline No. 14 were for the greater part incandescent and were being perpetually sprayed with water from a manual fire-engine worked by four men. About three weeks before the explosion, the fire decreased, and soon appeared to have been completely extinguished. Nevertheless, the heat at the working-face was great, the temperature occasionally exceeding 86° Fahr. Thanks to the circulation, however, of abundant cool air, the temperature had diminished about a week before the explosion to an average of 68° Fahr. Within the last three days the reappearance of smoke was noted, and the heat of the fallen material had increased again to such an extent that it was found necessary to spray the flaggy shales before clearing them away, as they were otherwise too hot to handle. Apart from this, neither the pitmen nor the supervising officials who went along the incline shortly before the disaster observed anything unusual: there was no perceptible evolution or accumulation of fire-damp or other combustible gases. Suddenly, however, these very officials were thrown to one side by a violent blast of air; they immediately withdrew the workpeople who were busied in the clearing operations in the haulage-way, and hastened back with them to incline No. 14, where they met the shift at work there; most of its members having sustained

more or less severe burns, were immediately brought to bank and conveyed to the hospital. The injured men stated that a flame, accompanied by a not very loud report, had suddenly flashed up from the heap of coal lying in the incline, its action being confined to the upper portion thereof, that is, to heights exceeding 30 inches above the floor.

An inspection of the site of the explosion a few hours later failed to reveal any damage to the timbering of the incline, nor was any coal-dust observed below the brattice. But the gauzes of the safety-lamps found there were in part covered with dust, and clearly recognizable beads of coke were sticking to some of them: the general condition of the lamps was such as to preclude any idea that they had originated the ignition of the explosive gases, and the actual cause of the explosion remains undetermined. Chemical analyses of samples of the atmosphere from incline No. 14, carried out a fortnight before the accident, showed that the highest percentage therein of pit-gases (including carbon monoxide) was only 0·72. It is true that the renewal of the conflagration after these samples had been taken will have entailed an increase in the volume of dangerous gases present: these, commingled with the air circulating alongside the horizontal brattice, may well have formed an explosive mixture that was ultimately driven by the eddying air-currents into contact with flame arising from the smouldering pit-fire, and thus ignited.

At the "Consolid. Deutschland" colliery, in the South Beuthen mining district, a coal-dust explosion took place at 2·30 p.m. on February 20th, 1907, in consequence of which a hewer sustained immediate mortal injury from internal burns, and another hewer and two hauliers were suffocated by afterdamp. At the site of the explosion forewinning was going on in the Sattelflötz-Niederbank seam, between the 1,000-foot and 1,300-foot levels; this seam yields a good coking coal, is 11½ feet thick, and makes a fair amount of dust. The measures are regularly bedded, and dip about 12 degrees. The course of the ventilation is described and figured, and it is observed that the working-face and the roadways generally were dry, but that the bottom-drift of the 1,300-foot level was wet. For shot-firing, cartridges of compressed powder were in use; at every working-place there were boxes containing clay and fine ashes for tamping, and vessels full of water to be used in spraying the workings before shot-firing. There was no surviving eye-witness of the disaster, as all the victims expired before it was possible to rescue them. An inspection of the workings on the following morning showed that a number of holes had been drilled for shot-firing, that one shot had been fired making a cavity 4¼ feet deep, one shot had "blown out," and no cartridges had been inserted in the other drill-holes. All exposed surfaces were covered with a layer of brownish-black velvety soot, which was about a sixth of an inch thick in the immediate neighbourhood of the working-place where the explosion started, and diminished gradually as the distance from that point increased. Silvery beads of coke were also sprinkled over these surfaces, diminishing in number in the same ratio as the soot-layer decreased in thickness. Much damage was done to timbering, brattices, dams, etc. The only assignable cause of the disaster is the ignition of coal-dust by the "blown-out" shot. The first shot, in bringing down a certain amount of coal, had filled the ambient atmosphere with dust which was ignited by the flame of the second ("blown-out") shot. It is said that, before the disaster, there was no deposit of coal-dust on the timbering.

At about 9·30 a.m. on April 24th, 1907, an explosion of pit-gases took place at the Scharnhorst colliery, Brackel (Westphalia), whereby seven pitmen sustained severe injury. Four of them died within a week, and the three

others were incapacitated for a considerable time. The explosion occurred at the third deep level in the western district, in the workings of seam No. 2, which belongs to the bituminous-coal group. It is the lowermost seam worked in the Scharnhorst pit, is about 6 feet thick, and dips from 55 to 70 degrees northwards. A not inconsiderable evolution of gas has been observed from it. In the morning of April 24th, a hewer noticing a voluminous accumulation of pit-gas in the working-place where the explosion subsequently occurred, at first attributed this to some interruption in the ventilation; but, finding that such was not the case, he sought to strengthen the air-current by opening a particular brattice-door, and, accompanied by another hewer, returned to the working-place to pursue his investigations. About 55 yards from the face, the men were met by a strong blower of gas, which caught fire at their lamps and started the explosion. The flames, as they swept onwards, ignited certain heaps of dry coal-dust in a place where nobody was at work at the time. Very little damage was done to timbering, etc., but a wooden brattice-door was smashed. Beads of coke and incrustations of coke were found on the timbering at the working-place where the explosion started, especially on surfaces directed to the east, and they increased gradually eastwards; but they were absent in places which had been well sprayed with water shortly before the disaster. The unusual accumulation of pit-gas was due to a temporary diminution in the supply of fresh air, under circumstances which are explained. The explosion is regarded as directly due to the careless manner in which the hewers above-mentioned went about searching for escaping pit-gas in defiance of all the regulations. The lamps in use at the Scharnhorst colliery are Wienpahl benzine safety-lamps with double gauzes, friction-igniters, and magnetic locks. On examination one of the hewers' safety-lamps was found to be in a slightly defective condition, and the result has been to make a slight alteration in the construction of the Wienpahl lamp.

At the Lothringen colliery, Gerthe, Westphalia, a coal-dust explosion took place at 7 a.m. on October 8th, 1907, whereby five persons sustained more or less severe injury. The disaster appears to have been due to the flames of four shots (fired with gelatine-dynamite cartridges by means of safety-igniters) having unexpectedly spread back into places where there was an accumulation of coal-dust, and possibly but not probably of pit-gases also near the roof. The results of the official enquiry point to a dust-explosion pure and simple, which fortunately was not of great extent. L. L. B.

UNDERGROUND FIRES IN MINES.

La Lutte contre les Feux Souterrains. By A. Aron. *Annales des Mines*, 1908, *series* 10, *vol. xiii., pages* 465-530, *and* 21 *figures in the text.*

At the outset the author states that he is in this memoir preoccupied with only one division of the subject—the best method of combating underground fires, once they have started. He defines the other two divisions as (1) the investigation of the causes of spontaneous combustion, and (2) the study of the most effective precautionary regulations.

In the first part of the memoir, comprising four chapters, the main principles of the methods which have so far been adopted in battling with underground fires are set forth; and in the second an account is given of certain conflagrations which had more or less serious results, and are regarded as especially instructive examples.

Setting aside fires due to such purely fortuitous causes as ignition of timbering, etc., by naked lights or a ventilation-furnace, the author directs attention to the most usual source of conflagration in mines—the

spontaneous combustion of coal. The first chapter deals with the recognition of fires due to this cause: everything, it is pointed out, depends on the speedy discovery of a fire, and therefore extreme vigilance is demanded of the officials in a mine subject to such occurrences. In the second chapter the methods of attacking the fire, once discovered, are discussed. Passing briefly over gob-fires, wherein the method of shutting-off is the obvious remedy, the author deals more particularly with the case of a pillar of coal in a state of ignition. The construction of masonry-dams and judiciously calculated modifications of the air-current are among the palliatives indicated. Supposing, however, that the maintenance of the ignited pillar is by no means a necessary condition of the continuance of mining operations, there are two possible methods of dealing with the fire: (*a*) is that of direct attack, which involves slicing-down of the pillar, followed by or rather accompanied by simple water-spraying at high pressure or by *embouage* (slow injection of water carrying in suspension finely-divided solids, which are deposited in the fissures of the mass and thus make it air-tight). The precautions properly attendant on this method are described, including provisional timber-dams luted with clay, assiduous regulation of the air-currents, and untiring supervision, special attention being directed to the risks of explosion.

The second method (*b*), that of indirect attack, or more plainly, abandonment of the seat of fire, is the subject of the third chapter. Meanwhile, the conditions which favour direct attack are, briefly stated, as follows: the seam must not be a fiery one; the conflagration must not extend far up in the coal or into the shales of the roof; the necessary appliances must be at hand (compressed air, water at high pressure, finely divided solids); and the ventilation-system must be in satisfactory order. The second method presupposing the damming-off of the seat of fire, the points considered in some detail are—where the dams are best placed, how they are best built, and in what order they had best be closed up.

In the fourth chapter the methods of recovering the dammed-off area form the subject of a brief discussion, in the course of which the contrivance of the "ventilation-lock or compartment" (*sas d'aérage*), apparently originated by Mr. Henri Fayol, thirty years ago, is described.

The second part of the memoir begins with a short account of fires due to the use of naked lights. Then two accidents are described, actually due to falls of rock, brought about by water-jets in the course of spraying. Cases of explosions occurring in the course of direct attack of a fire (method *a*) are also recorded, naturally followed by a description of explosions which took place during the process of dam-building. The disastrous results which have sometimes ensued on a calculated change in the ventilation are exemplified, and the author's final conclusions are that the absolute air-tightness of a dam must never be assumed, however carefully it may have been built and maintained. Further, that when a mine is on fire, not only does the slightest disturbance in the normal course of the ventilation (such as the change in direction of an air-current) constitute a fearful risk; but the right determination of the course which the ventilation is to follow is really the prime factor of security. L. L. B.

THE SALT-MINING INDUSTRY IN THE RUSSIAN EMPIRE.

Die Salzindustrie und der Salzhandel Russlands zu Beginn des zwanzigsten Jahrhunderts. *By* F. THIESS. *Zeitschrift für das Berg-, Hütten- und Salinenwesen im preussischen Staate*, 1907, *vol. lv., Abhandlungen, pages* 282-288.

It would appear that the latest available official statistics are those for the year 1902, when the output of salt in the Russian Empire amounted to 1,847,082 tons or thereabouts, 26·73 per cent. of which was derived from rock-salt, 53·13 per cent. from lagoon or lake-salt, and 20·14 per cent. from pumping of brine. There had been a practically continuous increase in output during the decade 1893-1902.

The principal centres of rock-salt mining are the government of Yekaterinoslav, including the districts of Bakhmut and Slavyansk in the Donetz basin, the province of Orenburg, the Caucasus and the Transcaspian region. The most productive areas are those which lie within the governments of Yekaterinoslav and Orenburg. Although mining operations were not started on the Bakhmut and Slavyansk deposits until the seventies, their situation in Central Russia, in a thickly populated region well served by railways, proved especially favourable to the rapid development of the industry. The salt is of excellent quality, and the mines can be worked all the year round: and thus the government of Yekaterinoslav alone accounts for well nigh 85 per cent. of the annual output of rock-salt in Russia.

The Iletskaya-Sachita deposits, where 1,640 million tons of rock-salt are in sight, are linked up by a branch-line to the Orenburg-Tashkent railway. They are the only mines that are worked in the government of Orenburg. Rock-salt is known to occur in the Astrakhan district, but is not worked.

The lake or lagoon-salt obtained by natural atmospheric evaporation is designated *samosadochnaya soly* (self-separated salt), while that which is obtained from sea-water led into basins or from artificial saline lakes is termed *soly basseinovaya* (basin-salt). The chief centres of this industry lie along the coasts of the Black and the Caspian Seas, more especially in Tauris, the Khersonese, Astrakhan, and Bessarabia; also in the territory of the Don Cossacks, the Urals, the Caucasus, Transcaspia, Russian Turkestan, and Siberia. Along the coasts of the Black and the Caspian Seas, no less than 3,000 salt-lagoons and salt-marshes are to be found, among which may be mentioned Lake Elton (84 square miles in area) and Lake Baskunchak (49¼ square miles). Since 1882, operations have been suspended on Lake Elton, on account of the dearth of proper ways of communication; but Lake Baskunchak is linked up by a railway with the Volga, and yields a salt of prime quality which reaches markets (where it finds a ready sale) by means of water-transport. Some account is given of the important salt-lagoons of the Crimea, and of those in the neighbourhood of Odessa. In Siberia the salt-lake industry flourishes in the steppe-regions of Semipalatinsk, Semiryechensk, and Akmolinsk, in the south-western portion of the province of Tomsk, in that of Yakutsk, and in Transbaikalia. In the Semipalatinsk-Semiryechensk area no less than thirty-nine salt-lakes are grouped along the Irtish (sixteen along the right bank, twenty-three along the left), and of these perhaps the most important is the Koryakovo Lake, which in 1902 yielded 27,453 tons of salt. As to rock-salt deposits in Siberia, their great distance from possible markets and the absence of convenient means of access are perhaps at present the chief obstacles to mining operations on anything like an adequate scale.

The centres of the brine-industry are the government of Peru, those of

Kharkov and Yekaterinoslav, Vologda and Archangel, Warsaw, and the Caucasus and Siberia. Although Perm no longer retains its ancient primacy, dating from the early seventeenth century, it still plays an important part in the total output of the Empire. The methods of working are primitive in that region of the Urals, and, just as in days gone by, the only fuel used by some brine-evaporating works is wood. Russia exports comparatively little salt, and most of that to Persia; the imports are about 2½ times greater than the exports. The salt-industry of the Empire was long stunted by Government monopolies and injudicious taxation, most of these being swept away in 1880; but the industry is yet far from attaining the development which the natural resources of the Russian Empire would justify. L. L. B.

ACCIDENTS AT ELECTRIC INSTALLATIONS AT PRUSSIAN MINES DURING 1907.

Unfälle in elektrischen Betrieben auf den Bergwerken Preussens im Jahre 1907. [Official]. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussischen Staate*, 1908, *vol. lvi., pages* 503-519, *and* 8 *figures in the text.*

It is hardly practicable, within the limits of an ordinary abstract, to give details of all the accidents described in the official report, but the following may be regarded as fairly typical.

At the Dubensko Colliery, in the mining district of South Gleiwitz, a man who was carrying out repairs to an underground pumping-engine, when lifting a portable electric lamp from the iron-plated floor of the engine-room, was instantaneously killed by a shock due to short-circuiting on May 15th, 1907. A defect of insulation within the lamp had allowed the tension of the alternating current (120 to 130 volts) to pass over to the external metallic portions of the lamp. It is true that the handgrip by which it was customary to grasp the lamp consisted of insulating material; but, as there was bare metal at both ends of this, the victim must have touched this bare metal and thus completed a short circuit to earth. It may be added that, as the man had previously been at work in the sump, his clothing and footgear were wet; and, the temperature being high, he was sweating all over.

On May 26th, 1907, at the Consolid. Giesche Colliery, in the mining district of South Kattowitz, a putter was killed under rather curious circumstances. An electric lighting system, bearing an alternating current at 220 volts was carried in gas-piping in the brick wall of a haulage-way. The conductors were ordinary guttapercha-covered wires with insulators at intervals temporarily affixed by means of wooden fittings to the roof-supports. Within the gas-piping a short-circuit had been established owing to defective insulation; but the fuzes (which had been calculated for 15 ampères) remained unmelted, as the gas-piping was comparatively well insulated by the brickwork. A cry from the victim, who was found hanging by one arm to the top rim of an iron tub, brought his mates to his aid; the first who vainly attempted to release him received a violent shock, and it was found necessary to switch off the lighting system, by which time the victim was beyond help. The wooden corduroy roadway on which the tub was standing was soaking wet, as also was the footgear of the victim. How exactly the accident came about, through contact of the tub with the gas-piping or otherwise, remains undetermined. Measures have been taken to replace the lighting system by a new installation.

Two fatal accidents took place on April 13th and June 1st respectively in the Meurostollen brown-coal mine, at Senftenberg, mining district of West Cottbus. In the first case, a pump worked by an electric motor was fixed up

between the 9th and 10th deep levels, the current at a tension of 500 volts being supplied from above ground. It is supposed that an overseer, in the act of establishing a contact between the connecting cable to the electromotor and the switchboard a few yards distant therefrom, accidentally trod on a spiral steel-wire enveloping the cable, broke it, and thus made contact between the broken wire and the core of the cable. He was standing with wet feet on a damp floor, and his body receiving the full tension of the current formed a short circuit to earth, whereby he met his death. In the second case, the man in charge of an electrically driven pumping-engine in an opencast working, fell dead in the act of switching it on. It is supposed that he accidentally stretched a single finger of his hand beyond the switch-cover, and thus made contact with live wires.

At the washery connected with the Jenny Otto sulphidic ore-mines in the Ost-Beuthen district, an accident happened whereby an engine-room attendant was incapacitated for about a month, owing to the carelessness of the man in charge of the motor, when switching it on after an interval between shifts. Subsequent enquiry showed that, generally speaking, in Upper Silesia at all events, the men who are in charge of electromotors are not well-educated enough to understand fully the meaning and object of the regulations which govern the use of electrical plant, and therefore are unable to realize the consequences of the slightest negligence or infraction of the rules on their part.

The charge of negligence does not apply, however, to the uninstructed man alone. Thus, at the Gouley Colliery, in the Aix-la-Chapelle mining district, an electrician who had been engaged for seven months in the setting-up of a new plant met with his death primarily through neglecting, despite repeated warnings from the superintending engineer, to wear rubber gloves and rubber shoes. No less than three of the other nine fatal accidents described were due to gross carelessness or to unauthorized meddling with parts of apparatus on the part of the victims.

In all, twenty-six accidents are described, fourteen of which were attended with fatal results. Twenty-one accidents took place at collieries and lignite-mines, three at potassium-salt mines, and two at metalliferous mines. In a very few cases the cause was traced to previously unnoticed defects of insulation, and in still fewer to defects inherent in the apparatus. L. L. B.

LIST OF FATAL AND NON-FATAL EXPLOSIONS OF FIRE-DAMP OR COAL-DUST, AND BAROMETER, THERMOMETER, ETC., READINGS FOR THE YEARS 1907 AND 1908.

COMPILED BY PERCY STRZELECKI.

The barometer, thermometer, etc., readings have been supplied by the permission of the authorities of Glasgow and Kew Observatories, and give some idea of the variations of atmospheric temperature and pressure in the intervening districts in which mining operations are chiefly carried on in this country.

The barometer at Kew is 34 feet and at Glasgow 180 feet above sea-level. The barometer readings at Glasgow have been reduced to 32 feet above sea-level, by the addition of 0·150 inch to each reading, and the barometrical readings at both observatories are reduced to 32° Fahr.

The statistics of fatal and non-fatal explosions in collieries have been obtained from H.M. Inspectors of Mines.

The times recorded are Greenwich mean time, in which midnight equals 0 or 24 hours.

TABLE I.—SUMMARY OF EXPLOSIONS OF FIRE-DAMP OR COAL-DUST IN THE SEVERAL MINES-INSPECTION DISTRICTS DURING 1907.

Mines-inspection District.	Fatal Accidents.			Non-fatal Accidents.	
	No.	Deaths.	Injured.	No.	Injured.
Cardiff	0	0	0	8	11
Durham	0	0	0	11	17
Ireland	0	0	0	0	0
Liverpool	0	0	0	1	2
Manchester	1	1	1	1	1
Midland	1	1	0	8	8
Newcastle-upon-Tyne ...	3	10	8	10	15
Scotland, East	1	3	0	42	55
Do. West	7	7	1	35	45
Southern	0	0	0	2	2
Stafford	1	1	0	11	13
Swansea	4	21	5	34	44
Yorkshire	0	0	0	5	7
Totals	18	44	15	168	220

TABLE II.—LIST OF FATAL EXPLOSIONS OF FIRE-DAMP OR COAL-DUST IN COLLIERIES IN THE SEVERAL MINES-INSPECTION DISTRICTS DURING 1907.

1907.	Colliery.	Mines-inspection District.	Deaths.	No. of Persons Injured.
Jan. 29, 11·15	Philpstoun (oil-shale) ...	Scotland, East ...	3	0
Feb. 26, 6·5	Griff (Clara)	Midland	1	0
Mar. 5, 18·15	Genwen	Swansea	6	0
,, 19, 17·40	Benwell	Newcastle-upon-Tyne	4	0
April 3, 16·30	Wester Queenslie (No. 2 Pit)	Scotland, West ...	1	0
May 2, 20·30	Wester Gartshore ...	Do. ...	1	0
,, 18, 13·0	Great Wyrley	Stafford	1	0
June 20, 8·0	Carmyle (No. 1 Pit) ...	Scotland, West ...	1	0
July 23, 20·0	Greenfield, Threestonehill (No. 7 Pit)	Do. ...	1	0
,, 28, 7·30	Over Dalserf (No. 2 Pit)	Do. ...	1	0
Aug. 8, 16·0	Bradford	Manchester	1	1
Sept. 2, 5·15	Berryhill (No. 2 Pit) ...	Scotland, West ...	1	0
,, 9, 4·30	Dulais	Swansea	3	1
Oct. 1, 20·45	Townhead (No. 43 Pit) ...	Scotland, West ...	1	1
Nov. 10, 8·30	Seven Sisters	Swansea	5	3
,, 26, 13·50	Whitehaven (William Pit)	Newcastle-upon-Tyne	5	7
Dec. 14, 14·15	Dinas Main	Swansea	7	1
,, 18, 8·20	Hazlerigg	Newcastle-upon-Tyne	1	1
			44	15

TABLE III.—LIST OF NON-FATAL EXPLOSIONS OF FIRE-DAMP OR COAL-DUST IN COLLIERIES IN THE SEVERAL MINES-INSPECTION DISTRICTS DURING 1907.

1907.	Colliery.	Mines-inspection District.	No. of Persons Injured.
Jan. 2, 13·20...	Marley Hill	Newcastle-upon-Tyne	1
,, 4, 9·45...	South Medomsley	Do.	1
,, 4, 11·15...	Llwyn	Swansea	1
,, 7, 11·30...	Porthdafen (No. 2 Pit) ...	Do.	1
,, 8, 14·30...	British Rhondda	Do.	2
,, 12, 9·0 ...	Llwyn	Do.	1
,, 15, 6·30...	Chickenley Heath ...	Yorkshire	1
,, 15, 21·0 ...	Bowhill (No. 2 Pit) ...	Scotland, West ...	3
,, 17, 2·0 ...	Lower Darwen	Manchester	1
,, 18, 15·0 ...	Lewis Graigola	Swansea	2
,, 28, 4·45...	Etherley	Durham	1
,, 28, 7·0 ...	Cowpen	Newcastle-upon-Tyne	1
,, 28, 7·30...	Broadfields (No. 18 Pit) ...	Stafford	1
,, 28, 11·0 ...	Sipton (lead mine) ...	Newcastle-upon-Tyne	4
,, 28, 14·0 ...	Canderigg (No. 1 Pit) ...	Scotland, West ..	1
,, 29, 14·15...	Elba	Swansea	1
,, 29, 15·0 ...	Bonville's Court	Do.	1
,, 30, 9·30...	Lanemark (Rigfoot Pit) ...	Scotland, West ...	1
Feb. 5, 13·30...	Oakbank (oil-shale) ...	Scotland, East ...	1
,, 5, 15·30...	Prestongrange	Do. ...	3
,, 7, 21·30...	Cawdor	Swansea	2
.. 9. 6·30...	St. George	Do.	1
,, 9, 13·30...	Nunnery	Yorkshire	2
.. 15, 20·0 ...	North Blaina Slope ...	Southern	1
,, 15, 20·0 ...	South Rhondda	Cardiff	1

TABLE III.—*Continued.*

1907.	Colliery.	Mines-inspection District.	No. of Persons Injured.
Feb. 15, 16·30...	Gateside	Scotland, West ...	1
,, 19, 6·30...	Glenboig (fireclay) ...	Scotland, East ...	1
,, 19, 13·30...	Cobbinshaw (oil-shale) ...	Do. ..	1
,, 20, 2·0 ...	Glencraig	Do. ...	1
,, 20, 7·30...	Broomrigg (No. 3 Pit) ...	Scotland, West ...	2
,, 27, 4·45...	Pumpherston (No. 5 Pit, oil-shale)	Scotland, East ..	1
,, 27, 13·0 ..	Blairhall	Do. ..	1
Mar. 1, 8·30...	Clyne Valley	Swansea	2
,, 1, 9·0 ...	Newliston (oil-shale) ...	Scotland, East ..	1
,, 5, 15·0 ...	Craig Merthyr	Swansea	1
,, 9, 8·0 ...	Auchenharvie (No. 5 Pit) ...	Scotland, West ...	1
,, 13, 13·30...	Wallbutts	Stafford	1
,, 13, 17·0 ...	Addison	Newcastle-upon-Tyne	1
,, 13, 17·0 ...	Cynon	Swansea	2
.. 14, 11·30...	Britain	Midland	0
.. 16, 6·35...	Hopetoun (oil-shale) ...	Scotland, East ...	1
,, 18, 6·0 ...	Oakley	Do.	1
,, 20, 1·0 ...	Skellyton (No. 3 Pit) ...	Scotland, West ..	1
,, 23, 1·30...	Maesymarchog	Swansea ...	1
,, 29, 18·0 ...	Queenslie (No. 2 Pit)	Scotland, West ...	1
April 3, 20·15...	Blaenavon (Big Pit) ...	Southern	1
,, 9, 20·0 ...	Dulais	Swansea	1
,, 10, 6·30...	Cowdenbeath (No. 10 Pit)	Scotland, East ...	1
,, 10, 19·15...	Raglan	Cardiff	1
,, 11, 14·0 ...	Porthdafen (No. 2 Pit) ...	Swansea	1
,, 12, 7·0 ...	Raglan	Cardiff	1
,, 17, 16·40...	Prestongrange	Scotland, East ...	1
,, 18, 7·0 ...	Bedlay	Scotland, West ...	2
,, 26, 16·30...	Coursington	Scotland, East ...	1
,, 27, 2·30...	Cannock Wood	Stafford	1
,, 29, 7·0 ...	Pennyvenie (No. 2 Pit) ...	Scotland, West ...	1
,, 30, 11·0 ...	Giffnock (No. 2 Pit) ...	Do. ...	1
May 2, 11·30...	Benarty	Scotland, East ...	1
,, 2, 20·0 ...	Cwmteg	Swansea	2
,, 3, 6·10..	Broadfields (No. 18 Pit)	Stafford	1
,, 6, 5·30...	Hummerbeck	Durham	1
,, 10, 13·45...	Meiros	Cardiff	1
,, 10, 3·0 ...	Queenslie (No. 1 Pit) ...	Scotland, West ...	2
,, 13, 12·45...	Silver Hill	Midland	3
,, 15, 19·0 ...	Newbattle	Scotland, East ...	1
,, 17, 10·30...	Meiros	Cardiff	3
,, 20, 21·0 ...	Bowhill (No. 2 Pit) ...	Scotland, West ...	1
,, 23, 19·0 ...	Hazlerigg	Newcastle-upon-Tyne	2
,, 27, 7·15...	Skellytown (No. 3 Pit) ...	Scotland, West ...	1
,, 30, 8·30...	Newton (No. 2 Pit) ...	Do. ...	2
June 3, 14·0 ...	Elba...	Swansea	1
,, 5, 10·30...	Harton	Newcastle-upon-Tyne	1
,, 7, 11·30...	Braichycymmer (No. 2 Slant)	Swansea	1
,, 7, 12·0 ...	Springside (No. 11 Pit) .	Scotland, West ...	2
,, 9, 10·30...	Cynon	Swansea	1
,, 9, 22·0 ...	Dalmeny (oil-shale)	Scotland, East ...	2
,, 10, 4·40...	Brusselton	Durham	1
,, 12, 8·0 ...	Hattonrigg (No. 3 Pit) ...	Scotland, West ...	1
,, 16, 23·30...	Conduit (No. 4 Pit) ...	Stafford	1
,, 17, 11·30...	Lumphinnans	Scotland, East	1
,, 18, 12·0 ...	Saunder Clough	Yorkshire	1
,, 24, 11·20...	Hopetoun (oil-shale) ...	Scotland, East ...	1

TABLE III.—*Continued.*

1907.	Colliery.	Mines-inspection District.	No. of Persons Injured.
June 24, 17·0 ...	Moody's Graigola ...	Swansea	1
,, 26, 17·45...	Gilwen	Do.	1
,, 28, 21·0 ...	New Cwmgorse	Do.	1
,, 28, 23·0 ...	International	Do.	1
July 12, 19·0 ...	Holytown (No. 5 Pit) ...	Scotland, West ...	2
,, 15, 9·0 ...	Auchincruive (No. 2 Pit)...	Do.	1
,, 17, 8·30...	Rankinston (No. 1 Pit) ...	Do.	1
,, 18, 9·0 ...	Onllwyn	Swansea	1
,, 18, 7·30...	Barglachan (No. 2 Pit) ...	Scotland, West ...	1
,, 22, 7·10...	North Motherwell	Scotland, East ...	3
,, 22, 8·15...	Hamstead	Stafford	1
,, 23, 1·0 ..	North Motherwell	Scotland, East ..	2
,, 26, 14·45...	Auchincruive (No. 1 Pit)	Scotland, West ..	1
,, 27, 11·0 ...	Craiglon	Swansea	1
Aug. 13, 16·30...	Binchester	Durham	2
,, 16, 20·0 ...	Woodhorn	Newcastle-upon-Tyne	1
,, 19, 23·0 ...	Dulais	Swansea	1
,, 27, 20·0 ...	Forge	Stafford	1
,, 28, 1·15 .	Shawfield	Scotland, East ...	2
,, 30, 15·15...	Auchinreoch (No. 2 Pit) ...	Scotland, West ..	1
Sept. 2, 8·0 ...	Dalzell and Broomside ...	Scotland, East ...	2
,, 2, 10·30...	Blackwell (A Pit)	Midland	1
,, 2, 11·0 ...	Bridgeness	Scotland, East ...	1
,, 3, 13·30...	Newbattle	Do.	1
,, 3, 7·30...	Lanemark (No. 2 Pit) ...	Scotland, West ..	1
,, 9, 8·45...	Britain	Midland	1
,, 9, 9·30...	Over Dalserf	Scotland, West ...	1
,, 9, 13·30...	Cornsilloch (No. 3 Pit) ...	Do.	1
,, 10, 3·0 ...	Swinhill (No. 2 Pit) ...	Do. ...	2
,, 13, 14·15...	Howmuir	Scotland, East ...	1
,, 13, 21·30...	Coppice	Midland	1
,, 17, 21·0 ...	Ffochriw	Cardiff	1
,, 18, 1·0 ...	Maritime	Do.	2
,, 21, 3·0 ...	Oakbank (oil-shale) ...	Scotland, East ...	1
,, 24, 7·45...	Stanghow (ironstone mine)	Durham	3
,, 25, 1·30...	Novadd	Swansea	2
,, 25, 10·0 ...	Porthdafen (No. 1 Pit)	Do.	1
,, 25, 13·15...	Ashtons Green	Liverpool	2
,, 25, 7·0 ...	Bowhill (No. 2 Pit) ...	Scotland, West ..	1
,, 27, 7·0 ...	Montgomeriefield (No. 1 Pit)	Do.	1
Oct. 1, 11·10...	Brownhills (No. 3 Pit) ...	Stafford	1
,, 2, 14·0 ...	Portland	Midland	0
,, 2, 15·15...	Blackwell (B Pit)	Do.	2
,, 5, 11·0 ...	Kilton (ironstone mine) ..	Durham	1
,, 8, 19·30...	Dulais	Swansea	3
,, 9, 12·15...	Bannockburn (No. 2 Pit) ...	Scotland, West ..	1
,, 13, 22·30...	Saline	Scotland, East ...	1
,, 15, 6·10...	Highley	Stafford	1
,, 15, 9·45...	Britain	Midland	0
,, 15, 12·0 ...	Glynea	Swansea	1
,, 15, 12·0 ...	Kippsbyre	Scotland, East ...	1
,, 15, 19·0 ...	Newfield	Durham	1
,, 17, 5·45...	Binchester	Do.	1
,, 18, 15·0 ...	Blairhall	Scotland, East ...	1
,, 19, 23·30...	Ellenborough	Newcastle-upon-Tyne	1
,, 23, 16 0 ...	Lumphinnans	Scotland, East ...	1
,, 27, 11·55...	Westgate	Yorkshire	1
,, 29, 14·30...	Parkneuk	Scotland, East ..	2
,, 31, 21·15...	Fairlie (No. 3 Pit)... ...	Scotland, West ...	2

TABLE III.—*Continued.*

1907.	Colliery.	Mines-Inspection District.	No. of Persons Injured.
Nov. 4, 12·0 ...	Canderigg (No. 2 Pit) ...	Scotland, West ...	1
„ 5, 0·30...	Oakbank (oil-shale) ...	Scotland, East ...	1
„ 6, 15·15...	Conduit (No. 3 Pit) ...	Stafford	3
„ 8, 20·30...	Cawdor	Swansea	1
„ 13, 13·30...	Tydraw	Cardiff	1
„ 14, 7·0 ...	Dunsyston	Scotland, East ..	3
„ 15, 21·0 ...	Motherwell	Do.	1
„ 16, 7·15...	Rosebank	Do.	1
„ 18, 15·0 ...	Forge	Stafford	1
„ 25, 7·0 ...	Cowdenbeath (No. 10 Pit)	Scotland, East ...	1
„ 26, 11·30...	North Motherwell	Do.	1
„ 26, 7·0 ...	Bannockburn (No. 2 Pit) ...	Scotland, West ..	1
„ 27, 4·15...	Carronhall	Scotland, East ...	1
„ 27, 7·0 ...	Glenboig (fireclay) ...	Do. ...	3
„ 28, 23·0 ...	Killan	Swansea	1
„ 30, 9·30...	Ynyscedwyn	Do.	2
Dec. 4, 14·0 ...	Braidhurst	Scotland, East ...	1
„ 4, 14·30...	Binchester	Durham	1
„ 8, 20·30...	Foulshiels	Scotland, East ...	1
„ 13, 21·0 ...	Gilbertfield (No. 1 Pit) ...	Scotland, West ...	1
„ 14, 4·0 ...	Tannochside (No. 2 Pit) ...	Do.	1
„ 18, 23·45...	Waterclough	Yorkshire	2
„ 22, 20·0 ...	Dalmeny (oil-shale) ...	Scotland, East ...	1
„ 23, 15·30...	North Skelton (ironstone mine)	Durham	4
„ 27, 10·0 ...	Cwmllynfell	Swansea	1
„ 30, 5·0 ...	South Medomsley	Newcastle-upon-Tyne	2
„ 30, 9·0 ...	Liverton (ironstone mine)	Durham	1
			220

TABLE IV.—SUMMARY OF EXPLOSIONS OF FIRE-DAMP OR COAL-DUST IN THE SEVERAL MINES-INSPECTION DISTRICTS DURING 1908.

Mines-inspection District.	Fatal Accidents			Non-fatal Accidents.	
	No.	Deaths.	Injured.	No.	Injured.
Cardiff	0	0	0	4	5
Durham	0	0	0	6	11
Ireland	0	0	0	0	0
Liverpool	1	75	0	0	0
Manchester	1	1	0	0	0
Midland	1	1	3	8	5
Newcastle-upon-Tyne ..	3	16	2	3	4
Scotland, East	5	7	5	30	34
Do. West . ..	8	12	5	47	60
Southern	2	13	0	1	1
Stafford	0	0	0	5	7
Swansea	1	2	4	19	23
Yorkshire	1	1	0	7	7
Totals	23	128	19	130	157

TABLE VI.—*Continued.*

1908.	Colliery.	Mines-inspection District.	No. of Persons Injured.
Sept. 6, 22·20...	Teversall	Midland	1
„ 8, 22·0 ...	Blairhall	Scotland, East ...	1
„ 9, 9·0 ...	Barglachan (No. 2 Pit) ...	Scotland, West ...	1
„ 9, 2·30...	East Plean	Do.	1
„ 10, 0·30...	Brusselton	Durham	3
„ 15, 10·15...	East Plean (No. 4 Pit) ...	Scotland, West ...	4
„ 19, 6·30...	Gilbertfield (No. 1 Pit) ...	Do.	1
„ 22, 20·15...	Blairhall	Scotland, East ...	1
„ 22, 5·0 ...	Graig Merthyr	Swansea	1
„ 25, 15·0 ...	Giffnock	Scotland, West ...	1
„ 26, 9·50...	New Selston	Midland	1
„ 30, 19·0 ...	Glencraig	Scotland, East ...	1
Oct. 1, 13·0 ..	Carriden	Do. ...	1
„ 2, 1·30 ...	Bridgeness	Do. ...	1
„ 7, 16·0 ..	Simpsonland (No. 1 Pit) ...	Scotland, West ...	1
„ 10, 7·30...	Coneygre (No. 3 Pit) ...	Stafford	1
„ 12, 6·30...	Law	Scotland, East ...	1
„ 18, 22·0 ...	Polquhairn	Scotland, West ...	2
„ 20, 17·0 ...	Swannick (Deep Pit) ...	Midland	1
„ 26, 7·0 ...	Hillhead (No. 13 Pit) ...	Scotland, West ...	2
„ 30, 16·0 ...	Swinhill	Do.	1
Nov. 2, 12·0 ...	Raglan	Cardiff...	1
„ 3, 7·40...	Redhill	Yorkshire	1
„ 6, 13·30 ..	Limefield	Scotland, East ...	1
„ 11, 10·0 ...	Auchenharvie (No. 5 Pit)	Scotland, West ...	1
„ 14, 9·30...	Duddingston	Scotland, East ...	1
„ 16, 7·20...	Dunnikier	Do. ...	2
„ 16, 21·0 ...	Giffnock	Scotland, West ...	1
„ 17, 16·30...	Elba...	Swansea	1
„ 23, 8·45 .	Victoria (No. 1 Pit) ...	Scotland, West ...	1
„ 23, 6·0 ...	Broomrigg (No. 3 Pit) ...	Do. ...	1
„ 26, 0·15...	Newbattle	Scotland, East ...	1
„ 27, 15·0 ...	Ellistown	Midland	0
„ 27, 12·30...	Broomhouse	Scotland, West ...	1
Dec. 2, 1·30...	Hattonrigg (No. 4 Pit) ..	Do. ...	1
„ 3, 19·30...	Tonhir	Swansea	1
„ 8, 7·5 ...	Helm	Yorkshire	1
„ 8, 21·45...	Desford	Midland	1
„ 10, 7·30...	South Duffryn	Cardiff...	1
„ 10, 9·0 ...	Oakenshaw	Durham	1
„ 10, 7·15..	Baptist End (No. 1 Pit) ...	Stafford	1
„ 10, 19·30...	Rosehall (No. 14 Pit) ...	Scotland, West ...	1
„ 10, 15·30...	Lanemark (No. 2 Pit) ...	Do. ...	1
„ 11, 13·30...	Glyncorrwg (North Pit) ...	Swansea	1
„ 11, 16·0 ...	Newbattle	Scotland. East ...	1
„ 15, 11·30...	Roman Camp	Do. ...	1
„ 17, 7·30...	Tonhir	Swansea	1
„ 18, 8·30...	Gartcosh	Scotland, West ..	1
„ 18, 4·0 ...	Kirkwood (No. 1 Pit) ...	Do. ...	1
„ 25, 13·0 ...	Springhill (No. 3 Pit) ...	Do. ...	1
			157

TABLE VII.—BAROMETER, THERMOMETER, ETC., READINGS, 1907.

JANUARY, 1907.

KEW.								GLASGOW.							
	BAROMETER.				TEMPERATURE.				BAROMETER.				TEMPERATURE.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.
1	29·579	29·613	29·493	29·386	50·9	38·4	SW	1	29·234	29·289	29·162	28·758	40·4	34·1	SSW
2	29·219	29·149	29·268	29·296	50·5	37·6	W	2	28·747	28·793	28·801	28·829	43·8	34·0	SW
3	29·099	29·343	29·509	29·785	44·0	36·8	W	3	28·920	29·203	29·547	29·779	39·3	33·4	NW
4	30·001	30·197	30 330	30·422	40·9	32·4	NW	4	29·975	30·123	30·141	30·085	38·4	31·8	WSW
5	30·381	30·347	30·280	30·226	48·8	34·3	SW	5	30·029	29·957	29·795	29·865	49·0	38·0	SW
6	30·194	30·347	30·414	30·505	48·6	36·4	WNW	6	29·987	30·124	30·220	30·302	45·1	38·3	WNW
7	30·536	30·556	30·506	30·526	45·1	33·5	SW	7	30·291	30·290	30·306	30·349	49·0	42·2	WSW
8	30·522	30·526	30·472	30·462	46·3	42·5	NW	8	30·345	29·340	30·277	30·237	47·4	44·2	SW
9	30·382	30·373	30·305	30·321	45·8	42·3	WSW	9	30·166	30·123	30·077	30·077	46·4	43·5	SW
10	30·298	30·326	30·314	30·332	47·3	43·3	W	10	30·047	30·061	30·077	30·196	47·4	40·3	WSW
11	30·379	30·587	30·646	30·683	45·3	34·9	N	11	30·322	30·428	30·441	30·400	45·1	38·0	W
12	30·652	30·585	30·455	30·445	48·4	34·3	W	12	30·317	30·220	30·170	30·212	49·7	43·1	W
13	30·448	30·541	30·501	30·476	48·4	44·1	WNW	13	30·290	30·349	30·216	30·180	47·0	39·9	WSW
14	30·432	30·424	30·393	30·435	46·3	44·6	W	14	30·131	30·119	30·094	30·163	48·2	44·9	SW
15	30·461	30·525	30·528	30·536	46·5	43·8	W	15	30·231	30·288	30·277	30·284	47·7	44·1	WSW
16	30·540	30·580	30·595	30·634	46·9	43·9	W	16	30·305	30·359	30·430	30·493	46·3	44·2	WSW
17	30·657	30·716	30·710	30·736	46·1	33·1	SE	17	30·526	30·555	30·589	30·634	45·6	42·2	SW
18	30·747	30·742	30·645	30·637	38·4	30·6	E	18	30·626	30·624	30·556	30·516	42·8	39·3	S
19	30·613	30·639	30·610	30·635	37·0	31·1	E	19	30·472	30·481	30·448	30·460	42·3	34·7	SE
20	30·608	30·639	30·613	30·613	40·0	32·9	ESE	20	30·426	30·427	30·421	30·444	43·7	39·8	SW
21	30·574	30·567	30·529	30·469	45·4	34·9	NNE	21	30·467	30·505	30·434	30·277	46·2	40·3	W
22	30·345	30·386	30·564	30·735	38·2	28·4	E	22	30·351	30·588	30·778	30·908	41·5	31·5	E
23	30·781	30·782	30·640	30·585	29·8	25·7	NE	23	30·957	30·975	30·905	30·833	36·7	27·0	E
24	30 525	30·514	30·465	30·460	29·0	24·1	E	24	30·668	30·553	30·393	30·341	30·7	21·0	W
25	30·427	30·431	30·344	30·332	33·1	26·8	NE	25	30·309	30·269	30·230	30·328	40·5	28·7	ENE
26	30·331	30·433	30·458	30·500	34·1	24·9	N	26	30·408	30·462	30·421	30·358	33·3	26·1	WNW
27	30·413	30·367	30·257	30·148	40·2	23·3	W	27	30·267	30·119	29·832	29·776	46·0	29·2	W
28	30·046	30·010	29·772	29·613	49·8	38·9	WSW	28	29·680	29·320	29·242	29·217	49·1	33·5	W
29	29·596	29·632	29·515	29·507	45·4	34·7	W	29	29·235	29·222	29·231	29·296	38·3	30·7	W
30	29·467	29·729	29·893	29·994	41·3	34·4	NNW	30	29·647	29·895	29·996	30·043	40·0	33·3	W
31	29·999	30·065	30·134	30·245	39·4	31·8	N	31	30·123	30·219	30·271	30·297	34·0	26·7	W

FEBRUARY, 1907.

1	30·279	30·338	30·366	30·438	37·6	30·0	N	1	30·311	30·317	30·321	30·357	36·3	21·8	NNE
2	30·496	30·541	30·497	30·462	35·9	28·6	NNE	2	30·387	30·410	30·375	30·345	38·3	31·8	SSW
3	30·367	30·315	30·215	30·201	33·7	29·4	NE	3	30·281	30·232	30·178	30·152	38·3	33·0	S
4	30·170	30·209	30·206	30·230	34·0	31·0	NW	4	30·121	30·154	30·239	30·382	39·1	30·3	NNW
5	30·272	30·350	30·387	30·397	37·0	33·3	NE	5	30·459	30·527	30·521	30·494	37·2	28·1	SE
6	30·315	30·221	30·080	30·026	38·6	32·2	E	6	30·371	30·258	30·048	29·911	37·3	24·3	NE
7	29·928	29·907	29·875	29·929	38·1	26·6	SSE	7	29·704	29·639	29·588	29·614	38·0	33·4	SSW
8	29·928	29·983	29·953	29·942	38·6	29·0	S	8	29·646	29·740	29·733	29·608	38·4	34·7	SW
9	29·841	29·780	29·735	29·785	42·1	29·2	S	9	29·377	29·381	29·403	29·441	41·3	33·8	WSW
10	29·789	29·828	29·752	29·666	44·3	29·4	SW	10	29·451	29·458	29·407	29·296	40·4	33·0	WSW
11	29·489	29·586	29 680	29·678	43·3	33·3	NW	11	29·300	29·379	29·421	29·364	36·3	30·4	W
12	29·451	29·143	29·003	29·067	46·2	34·3	S	12	29·246	29·189	29·213	29·337	36·3	32·1	NE
13	29·227	29·440	29·667	29·918	40·7	36·8	NNW	13	29·476	29·731	29·893	30 049	41·6	32·1	NNW
14	30·077	30·208	30·186	30·171	43·4	34·0	N	14	30·050	29·983	29·841	29·775	44·3	26·9	SSW
15	30·093	30·054	29·975	29·937	49·4	39·8	SW	15	29·710	29·632	29·540	29·660	49·4	42·0	SW
16	29·918	30·065	30·126	30·140	48·3	41·4	NW	16	29·727	29·848	29·771	29·583	47·3	36·3	W
17	30·037	30·016	30·023	30·131	50·9	42·9	W	17	29·514	29·656	29·840	29·890	48·6	41·1	W
18	30·099	30·020	29·872	29·793	49·5	42·2	SW	18	29·727	29·520	29·390	29·407	46·4	36·5	SW
19	29·835	29·817	29·539	29·126	51·1	40·3	SW	19	29·375	29·170	28·742	28·555	45·9	35·4	WSW
20	29·042	29·050	29·054	29·229	51·3	36·8	W	20	28·531	28·571	28·897	29·227	42·2	31·7	WNW
21	29·460	29·521	29·618	29·715	40·9	33·0	NW	21	29·349	29·497	29·595	29·633	39·9	31·2	NNW
22	29·695	29·759	29·776	29·858	37·7	29·4	NW	22	29·678	29·738	29·781	29·866	36·7	27·8	W
23	29 870	29·963	30·023	30·134	37·7	24·0	N	23	29·918	30·013	30·044	30·077	35·5	25·7	NNW
24	30·182	30·205	30·167	30·173	41·7	25·6	W	24	30·002	29·979	30·032	30·071	45·7	32·5	W
25	30·196	30·255	30·291	30·372	49·0	39·5	NNW	25	30·137	30·183	30·205	30·209	48·0	42·5	W
26	30·345	30·388	30·370	30·414	44·0	41·5	NW	26	30·199	30·225	30·234	30·310	48·5	42·5	W
27	30·433	30·498	30·491	30·528	47·9	32·2	N	27	30·354	30·426	30·433	30·460	49·4	41·8	W
28	30·523	30·569	30·514	30·509	47·8	29·0	WSW	28	30·450	30·469	30·406	30·358	44·6	33·3	NNE

MARCH, 1907.

KEW.								GLASGOW.							
	Barometer.				Temperature.				Barometer.				Temperature.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M	Max	Min.	Direction of wind at noon.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.
1	30·456	30·450	30·369	30·373	51·7	28·1	E	1	30·280	30·229	30·164	30·154	44·9	41·0	
2	30·327	30·333	30·280	30·305	50·5	30·2	SSW	2	30·146	30·194	30·208	30·264	48·7	40·7	SW
3	30·300	30·332	30·285	30·317	46·1	36·4	ENE	3	30·257	30·242	30·168	30·149	47·9	33·1	W
4	30·303	30·335	30·238	30·247	46·1	32·4	NE	4	30·164	30·189	30·099	30·017	48·1	41·9	S
5	30·177	30·127	29·999	29·991	45·7	29·8	SSW	5	29·800	29·675	29·792	29·886	45·6	37·3	S
6	30·021	30·154	30·243	30·360	48·9	32·3	N	6	29·945	30·059	30·109	30 065	46·1	35·3	WSW
7	30·335	30·284	30·082	29·938	47·3	31·9	SW	7	29·855	29·708	29·541	29·591	50·4	39·9	W
8	29·971	30·056	30·030	30·105	48·4	40·7	WNW	8	29·725	29·743	29·805	29·952	44·4	32·0	SW
9	30·176	30·263	30·172	30·066	46·9	38·7	NW	9	30·051	30·113	30·067	29·915	37·7	29·9	W
10	29·909	29·937	29·838	29·881	56·0	41·5	NW	10	29·771	29·695	29·727	29·885	44·4	28·9	WSW
11	29·958	30·238	30·388	30·477	43·6	31·0	NE	11	30·142	30·346	30·386	30·393	40·0	33·3	WSW
12	30·483	30·476	30·334	30·221	44·3	26·9	W	12	30·298	30·176	29·949	29·883	44·0	31·7	E
13	30·021	30·024	29·980	29·868	48·8	40·3	WNW	13	29·796	29·771	29·618	29·627	42·2	33·1	SSW
14	29·861	29·973	30·059	30·112	47·1	36·6	NW	14	29·721	29·867	29·859	29·736	41·6	31·9	W
15	30·000	29·940	29·887	29·873	53·3	40·7	W	15	29 520	29 499	29·510	29·486	49·9	39·0	W
16	29·834	29·797	29·674	29·491	49·8	46·6	SW	16	29·327	29·317	29·160	28·813	49·0	41·1	W
17	29·459	29·607	29·727	29·709	51·0	41·0	NW	17	29·008	29·198	29·302	29·194	45·4	37·3	SW
18	29·547	29·627	29·686	29·820	55·4	44·3	WNW	18	28·854	29·153	29·399	29·495	45·9	34·8	W
19	29·929	30·007	29·998	29·997	52·0	38·1	W	19	29·475	29·570	29·483	29·518	43·5	32·5	W
20	29·979	30·142	30·293	30·456	53·7	38·4	NW	20	29·651	29·947	30·203	30·307	48·8	38·0	WSW
21	30·503	30·512	30·407	30·420	56·0	32·8	WSW	21	30·257	30·217	30·081	30·116	50·2	41·5	NW
22	30·364	30·354	30·305	30·374	56·1	35·9	NW	22	30·137	30·211	30·252	30·346	47·4	39·3	WSW
23	30·393	30·405	30·353	30·351	53·0	34·3	N	23	30·354	30·365	30·304	30 281	50·1	36·8	NW
24	30·333	30·384	30·316	30·361	53·7	30·9	S	24	30·224	30·221	30·209	30·253	49·4	39·3	WNW
25	30·354	30·383	30·325	30·369	57·7	30·3	SSW	25	30·253	30·280	30·261	30·271	53·5	43·8	WSW
26	30·382	30·442	30·400	30·471	58·3	32·7	SSW	26	30·267	30·320	30·314	30·334	51·7	45·0	WSW
27	30·475	30·483	30·405	30·410	59·0	31·6	N	27	30·317	30·329	30·265	30·286	58·1	46·2	SW
28	30·383	30·361	30·222	30·201	62·3	29·1	ESE	28	30·259	30·249	30·114	30·054	55·7	37·0	SSW
29	30·144	30·097	29·992	29·981	64·4	34·9	S	29	29·981	29·931	29·794	29·779	61·5	39·0	SSW
30	29·958	29·976	29·921	29·944	64·8	35·1	S	30	29·791	29·867	29·874	29·892	50·5	42·0	W
31	29·936	29·943	29·869	29·903	66·4	37·9	SSW	31	29·862	29·862	29·792	29·820	58·1	35·0	SW

APRIL, 1907.

1	29·883	29·875	29·763	29·744	65·7	36·8	E	1	29·816	29·822	29·686	29·621	51·5	39·5	SW
2	29·628	29·530	29·443	29·369	63·6	42·3	S	2	29·480	29·367	29·235	29·216	62·5	44·1	SE
3	29·250	29·195	29·245	29·310	55·3	44·2	S	3	29·169	29·121	29·010	29·231	58·7	40·9	E
4	29·305	29·355	29·372	29·503	53·9	38·3	E	4	29·260	29·345	29·411	29·524	50·0	40·2	WNW
5	29·565	29·610	29·571	29·504	57·0	37·0	NW	5	29·576	29·540	29·363	29·158	53·6	35·1	ENE
6	29·348	29·388	29·296	29·324	55·6	39·9	SW	6	29·008	29·100	29·112	29·132	49·2	35·3	SW
7	29·242	29·317	29·361	29·442	51·1	34·0	WNW	7	29·104	29·149	29·153	29·210	47·9	34·5	NNE
8	29·436	29·426	29·469	29·522	52·4	40·2	W	8	29·253	29·328	29·365	29·432	51·4	36·3	WSW
9	29·519	29·553	29·554	29·656	51·2	42·3	SW	9	29·479	29·576	29·646	29·740	49·8	37·8	NE
10	29·729	29·807	29·783	29·795	49·7	39·0	N	10	29·786	29·846	29·858	29·922	45·8	41·0	ENE
11	29·761	29·764	29·669	29·673	48·6	35·3	ENE	11	29·894	29·928	29·903	29·907	44·8	39·5	ENE
12	29·609	29·559	29·459	29·415	49·2	42·5	E	12	29·827	29·807	29·778	29·807	46·4	40·0	ENE
13	29·362	29·484	29·520	29·610	57·1	44·1	S	13	29·767	29·761	29·748	29·781	46·6	38·0	NE
14	29·613	29·639	29·623	29·646	51·4	42·1	NE	14	29·765	29·765	29·722	29·727	47·9	35·3	ENE
15	29·622	29·592	29·514	29·519	52·9	40·9	NNE	15	29·688	29·668	29·578	29·600	51·1	39·8	ESE
16	29·456	29·514	29·467	29·535	55·3	41·3	N	16	29·606	29·606	29·550	29·569	55·2	36·7	N
17	29·576	29·638	29·682	29·862	55·1	38·3	N	17	29·578	29·726	29·852	29·963	46·8	37·7	N
18	29·924	30·000	29·979	30·007	46·0	33·1	N	18	29·989	29·984	29·911	29·931	44·5	31·9	W
19	30·013	30·069	30·056	30·145	51·1	33·2	WNW	19	29·931	29·958	29·924	29·926	51·9	35·0	NE
20	30·158	30·161	30·071	30·033	52·3	34·7	SSW	20	29·854	29·748	29·630	29·618	48·1	44·2	SW
21	29·934	29·913	29·887	29·973	50·6	45·8	SW	21	29·612	29·672	29·730	29·870	53·5	43·7	W
22	30·094	30·244	30·256	30·344	57·7	41·8	WNW	22	29·940	29·996	29·898	29·922	50·7	39·9	SW
23	30·306	30·319	30·262	30·301	60·1	44·0	W	23	29·926	29·996	30·022	30·048	53·4	48·0	WSW
24	30·265	30·279	30·262	30·309	69·8	51·9	NW	24	30·030	30·100	30·175	30·212	53·3	45·3	W
25	30·229	30·202	30·193	30·172	60·8	49·0	NNE	25	30·205	30·218	30·169	30·165	51·2	39·3	W
26	30·087	30·017	29·883	29·815	49·0	38·9	SSE	26	30·119	30·041	29·853	29·781	49·1	35·1	WNW
27	29 787	22·851	29·810	29·840	51·3	37·0	NNE	27	29·831	29·893	29·847	29·883	50·4	35·2	NE
28	29·846	29·886	29·853	29·847	50·9	35·2	N	28	29·836	29·761	29·685	29·673	50·4	38·7	WNW
29	29·754	29·727	29·690	29·716	54·2	41·9	NW	29	29·673	29·679	29·641	29·652	54·2	40·6	WNW
30	29·699	29·659	29·632	29·708	50·7	39·3	W	30	29·581	29·521	29·528	29·595	46·3	40·2	WNW

MAY, 1907.

KEW.								GLASGOW.							
	BAROMETER.				TEMPERATURE.				BAROMETER.				TEMPERATURE.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.
1	29·714	29·798	29·822	29·762	52·6	39·9	NW	1	29·661	29·686	29·468	29·095	49·0	40·1	WSW
2	29·420	29·360	29·362	29·437	52·8	44·0	W	2	28·983	29·020	28·864	28·714	28·698	46·0	36·8	SSW
3	29·445	29·456	29·408	29·268	54·1	43·4	W	3	28·918	29·005	29·053	29·038	49·9	39·1	W
4	29·483	29·615	29·691	29·800	57·1	44·1	W	4	29·033	29·167	29·279	29·473	48·4	40·7	W
5	29·812	29·785	29·651	29·625	58·3	38·1	E	5	29·578	29·695	29·724	29·739	55·6	43·1	SW
6	29·602	29·627	29·600	29·611	70·3	46·8	SE	6	29·689	29·720	29·725	29·764	52·3	43·3	E
7	29·616	29·672	29·804	29·888	57·8	46·4	W	7	29·698	29·646	29·581	29·599	51·4	44·0	NE
8	29·881	29·860	29·839	29·844	62·3	46·3	S	8	29·640	29·648	29·568	29·531	58·3	45·9	S
9	29·816	29·860	29·861	29·854	61·9	42·4	S	9	29·486	29·535	29·496	29·572	56·7	48·5	SSE
10	29·788	29·778	29·755	29·770	69·1	54·2	S	10	29·530	29·526	29·530	29·601	57·0	49·7	S
11	29·764	29·758	29·767	29·782	73·6	53·4	S	11	29·575	29·622	29·696	29·789	58·1	49·3	SSW
12	29·757	29·734	29·746	29·821	76·0	58·2	S	12	29·809	29·841	29·811	29·839	53·4	47·4	E
13	29·826	29·862	29·838	29·818	62·3	54·1	NW	13	29·738	29·806	29·803	29·857	62·6	46·1	SW
14	29·774	29·813	29·796	29·818	57·3	56·6	NNE	14	29·867	29·851	29·772	29·768	61·9	44·1	W
15	29·789	29·792	29·813	29·871	59·5	46·0	NE	15	29·745	29·763	29·778	29·848	57·0	45·1	W
16	29·890	29·935	29·951	30·068	59·0	47·7	N	16	29·865	29·943	29·998	30·102	52·8	42·1	NNE
17	30·118	30·163	30·165	30·212	54·1	44·0	N	17	30·181	30·223	30·235	30·271	54·6	39·7	N
18	30·183	30·173	30·145	30·169	50·6	38·9	NNE	18	30·277	30·273	30·215	30·215	52·5	37·4	E
19	30·134	30·100	30·043	30·046	51·7	36·9	N	19	30·182	30·135	30·047	30·048	52·4	39·9	ENE
20	30·010	29·971	29·921	29·911	49·8	36·0	N	20	30·033	30·035	30·020	30·024	49·1	41·8	ENE
21	29·849	29·804	29·761	29·748	52·9	39·6	NE	21	29·992	29·938	29·805	29·652	45·4	38·3	NE
22	29·723	29·731	29·710	29·702	61·8	43·9	NW	22	29·579	29·598	29·650	29·700	48·3	37·9	SW
23	29·631	29·634	29·607	29·633	69·3	51·3	S	23	29·743	29·808	29·816	29·752	50·6	43·0	E
24	29·619	29·692	29·827	29·955	65·7	47·7	S	24	29·658	29·739	29·836	29·947	52·7	44·2	E
25	30·000	30·005	29·944	29·957	69·0	42·9	ENE	25	30·004	30·058	30·059	30·057	57·3	46·3	ENE
26	29·941	29·967	29·982	30·031	60·2	52·7	NE	26	30·055	30·011	29·976	29·980	64·1	42·7	E
27	30·044	30·074	30·024	30·046	69·0	48·6	NE	27	29·991	29·996	29·989	30·101	68·8	45·3	SW
28	30·024	30·060	30·075	30·133	56·8	46·3	NE	28	30·140	30·180	30·189	30·228	52·3	42·5	E
29	30·128	30·148	30·144	30·175	55·0	44·4	ENE	29	30·234	30·219	30·152	30·142	52·7	37·7	ENE
30	30·128	30·099	30·002	29·925	60·5	45·5	SE	30	30·086	30·016	29·887	29·766	48·7	41·7	ENE
31	29·823	29·723	29·560	29·471	65·7	52·2	S	31	29·672	29·650	29·568	29·514	47·0	42·9	NE

JUNE, 1907.

1	29·403	29·424	29·446	29·508	64·8	53·7	N	1	29·478	29·481	29·476	29·485	51·1	44·3	NE
2	29·523	29·605	29·680	29·775	58·9	49·0	WNW	2	29·426	29·398	29·451	29·444	50·7	44·3	W
3	29·772	29·729	29·763	29·871	55·2	46·7	W	3	29·362	29·506	29·712	29·818	54·4	42·3	N
4	29·927	29·977	29·950	29·896	62·6	49·8	SW	4	29·847	29·832	29·743	29·647	49·4	42·8	ENE
5	29·795	29·692	29·655	29·670	65·6	52·0	SW	5	29·499	29·411	29·377	29·382	55·5	45·0	ENE
6	29·635	29·667	29·700	29·798	58·6	49·9	W	6	29·385	29·397	29·480	29·605	53·2	47·1	WSW
7	29·835	29·879	29·873	29·911	65·0	46·7	SW	7	29·660	29·702	29·711	29·722	55·9	44·9	W
8	29·913	29·929	29·873	29·858	68·1	54·4	SW	8	29·683	29·647	29·642	29·626	59·1	48·0	SSW
9	29·782	29·730	29·632	29·664	73·3	52·1	S	9	29·610	29·610	29·514	29·442	69·9	52·7	S
10	29·693	29·731	29·749	29·829	65·9	54·1	SW	10	29·424	29·433	29·372	29·389	62·5	51·6	SSW
11	29·868	29·900	29·859	29·769	66·5	51·0	SW	11	29·473	29·560	29·638	29·689	59·7	50·8	SW
12	29·645	29·651	29·661	29·690	63·4	53·9	SW	12	29·619	29·549	29·485	29·538	58·9	49·0	NE
13	29·716	29·845	29·910	30·008	65·3	53·0	SW	13	29·551	29·599	29·659	29·754	56·4	47·5	SW
14	29·998	29·992	29·997	30·009	66·4	49·9	SSW	14	29·778	29·863	29·785	29·749	56·9	45·6	S
15	29·955	29·944	29·885	29·937	60·0	52·9	SW	15	29·691	29·648	29·662	29·740	59·3	49·3	SSW
16	30·021	30·111	30·117	30·181	63·0	48·7	W	16	29·772	29·867	29·950	30·029	51·8	46·8	W
17	30·183	30·167	30·095	30·076	64·6	44·3	WNW	17	30·057	30·053	29·988	29·933	62·3	43·0	W
18	30·024	29·965	29·889	29·882	61·7	49·3	WSW	18	29·812	29·678	29·641	29·701	56·4	50·2	SSW
19	29·946	30·014	30·017	30·017	64·9	48·9	W	19	29·703	29·722	29·709	29·653	55·7	47·8	WSW
20	29·963	29·891	29·743	29·656	67·2	50·9	SW	20	29·583	29·565	29·473	29·463	52·1	47·9	SW
21	29·675	29·823	29·915	29·938	64·7	51·6	WNW	21	29·549	29·636	29·698	29·659	57·7	47·0	W
22	29·907	29·885	29·841	29·839	66·1	51·9	W	22	29·593	29·625	29·567	29·551	58·7	46·7	WSW
23	29·779	29·902	29·934	29·990	63·4	49·7	WNW	23	29·601	29·673	29·691	29·700	58·3	42·0	WSW
24	29·959	29·867	29·708	29·704	61·7	49·0	SW	24	29·509	29·463	29·422	29·393	52·9	44·8	W
25	29·628	29·749	29·737	29·687	58·7	49·0	W	25	29·432	29·481	29·461	29·489	57·7	41·0	W
26	29·728	29·802	29·792	29·825	68·0	54·5	WSW	26	29·490	29·441	29·368	29·429	55·7	47·3	SW
27	29·840	29·911	29·893	29·900	67·9	55·0	SW	27	29·438	29·540	29·570	29·586	56·8	46·8	SW
28	29·917	29·953	29·945	29·980	64·1	51·3	SW	28	29·685	29·765	29·819	29·880	58·8	48·1	W
29	29·961	29·936	29·870	29·902	65·1	47·0	N	29	29·891	29·902	29·884	29·938	61·5	45·3	W
30	29·866	29·836	29·833	29·852	58·7	49·0	N	30	29·954	29·989	29·948	29·951	58·1	46·7	NE

JULY, 1907

KEW.								GLASGOW.							
	Barometer.				Temperature.		Direction of wind at noon.		Barometer.				Temperature.		Direction of wind at noon.
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.		Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	
1	29·859	29·887	29·899	29·940	59·1	48·2	N	1	29·928	29·896	29·887	29·916	56·3	46·3	W
2	29·936	29·959	29·929	29·912	62·9	47·0	W	2	29·905	29·878	29·807	29·749	60·2	45·3	W
3	29·863	29·766	29·656	29·611	58·7	45·9	S	3	29·658	29·591	29·535	29·512	56·3	47·8	E
4	29·589	29·603	29·595	29·644	62·4	49·6	SSW	4	29·455	29·464	29·459	29·459	51·7	47·3	E
5	29·684	29·748	29·807	29·878	64·9	50·4	SW	5	29·467	29·506	29·552	29·604	57·3	45·1	W
6	29·926	29·953	29·934	29·967	63·4	49·0	W	6	29·613	29·673	29·713	29·788	56·9	46·5	W
7	29·955	29·958	29·924	29·923	63·9	50·5	SW	7	29·811	29·820	29·785	29·715	58·8	43·1	WNW
8	29·884	29·857	29·836	29·820	61·3	48·9	SSW	8	29·514	29·477	29·503	29·629	60·9	49·5	W
9	29·838	29·917	29·949	30·044	64·6	53·8	SW	9	29·709	29·781	29·842	29·943	59·3	47·3	NNE
10	30·064	30·069	30·190	30·330	61·9	47·5	NW	10	29·997	30·125	30·230	30·314	61·1	46·4	E
11	30·416	30·446	30·400	30·406	65·6	43·5	W	11	30·341	30·339	30·331	30·305	58·5	45·1	WSW
12	30·389	30·362	30·302	30·274	68·3	48·0	NW	12	30·256	30·258	30·194	30·151	59·9	51·9	SW
13	30·249	30·232	30·215	30·230	68·6	49·0	WSW	13	30·054	30·032	30·042	30·091	58·7	51·8	SW
14	30·214	30·237	30·223	30·265	69·2	57·5	SW	14	30·119	30·182	30·216	30·289	71·8	57·0	W
15	30·306	30·339	30·314	30·364	75·2	55·8	NE	15	30·351	30·411	30·431	30·466	74·0	62·0	E
16	30·366	30·359	30·303	30·302	72·9	56·0	N	16	30·474	30·458	30·376	30·356	80·6	59·4	W
17	30·260	30·276	30·220	30·208	67·9	54·5	N	17	30·344	30·301	30·227	30·204	82·4	57·2	ENE
18	30·162	30·144	30·070	30·094	73·9	53·6	NNE	18	30·162	30·114	30·051	30·082	73·0	51·2	NE
19	30·096	30·109	30·055	30·089	76·3	54·6	S	19	30·062	30·070	30·055	30·082	68·1	51·8	ENE
20	30·095	30·129	30·086	30·118	74·0	54·9	SE	20	30·100	30·120	30·098	30·105	68·1	52·3	NE
21	30·090	30·089	30·029	30·002	65·8	56·7	NE	21	30·069	30·065	30·009	30·002	63·4	51·0	E
22	29·954	29·933	29·874	29·882	72·4	56·4	SW	22	29·982	29·967	29·896	29·904	63·7	50·2	ENE
23	29·870	29·896	29·864	29·892	63·7	52·2	NE ?	23	29·886	29·875	29·844	29·891	64·8	49·7	E
24	29·904	29·929	29·897	29·931	67·4	49·5	E	24	29·909	29·931	29·927	29·935	59·9	49·0	NE
25	29·912	29·905	29·874	29·922	63·8	48·4	N	25	29·909	29·887	29·830	29·831	68·7	50·8	N
26	29·903	29·928	29·889	29·911	72·2	53·9	SW	26	29·790	29·761	29·710	29·684	64·1	51·4	SSW
27	29·871	29·902	29·927	29·990	71·0	60·3	SW	27	29·689	29·734	29·769	29·830	63·5	54·1	WSW
28	29·991	30·033	29·996	29·971	68·7	59·9	S	28	29·864	29·886	29·852	29·817	65·6	52·8	W
29	29·914	29·899	29·804	29·735	71·0	57·1	WSW	29	29·729	29·632	29·554	29·573	60·3	54·8	WSW
30	29·680	29·725	29·794	29·902	66·3	50·6	W	30	29·614	29·702	29·751	29·834	60·3	50·6	WNW
31	29·936	29·968	29·943	29·964	65·7	49·0	WNW	31	29·831	29·804	29·794	29·839	58·0	47·6	WNW

AUGUST, 1907.

1	29·969	30·014	30·016	30·061	63·0	45·6	NW	1	29·835	29·883	29·902	29·956	59·1	46·9	W
2	30·087	30·111	30·063	30·050	70·1	45·2	SSW	2	29·964	29·957	29·907	29·827	56·0	42·2	E
3	29·927	29·898	29·887	29·927	73·2	54·7	SSW	3	29·677	29·697	29·746	29·754	60·6	51·8	W
4	29·879	29·850	29·804	29·846	74·9	59·3	S	4	29·672	29·498	29·522	29·632	64·1	53·8	S
5	29·857	29·847	29·784	29·759	71·2	53·7	N	5	29·638	29·659	29·623	29·603	64·7	52·3	SW
6	29·769	29·797	29·822	29·872	67·6	54·3	SW	6	29·551	29·525	29·520	29·492	58·2	52·3	WSW
7	29·906	30·015	30·060	30·109	65·0	51·1	WSW	7	29·542	29·734	29·805	29·629	58·3	51·6	W
8	30·037	30·027	30·010	29·991	67·9	56·1	SW	8	29·559	29·655	29·687	29·672	61·6	52·5	WSW
9	29·939	29·921	29·843	29·807	70·3	60·8	SW	9	29·632	29·624	29·612	29·500	60·9	53·3	SW
10	29·751	29·730	29·721	29·840	69·5	55·1	SW	10	29·408	29·414	29·521	29·608	60·0	51·9	WSW
11	29·922	30·019	30·043	30·082	69·7	52·1	SW	11	29·653	29·676	29·711	29·739	60·8	50·1	SW
12	30·069	30·047	30·000	30·069	68·2	54·6	SSW	12	29·628	29·604	29·681	29·849	62·4	51·1	W
13	30·102	30·120	30·036	30·014	70·7	55·4	SW	13	29·894	29·857	29·615	29·669	66·0	50·5	S
14	30·008	29·960	29·831	29·717	71·8	60·3	SSW	14	29·662	29·646	29·642	29·564	63·4	53·4	SW
15	29·607	29·650	29·650	29·750	66·8	55·1	W	15	29·484	29·530	29·592	29·644	56·9	50·2	NE
16	29·816	29·920	29·905	29·792	63·7	52·1	WNW	16	29·711	29·737	29·615	29·463	57·1	47·9	SSW
17	29·747	29·855	29·889	29·929	70·1	58·0	W	17	29·457	29·615	29·657	29·671	62·0	48·0	W
18	29·804	29·815	29·798	29·831	69·6	56·1	W	18	29·615	29·611	29·555	29·533	61·3	49·9	WSW
19	29·835	29·849	29·876	29·986	64·1	49·7	SW	19	29·501	29·606	29·713	29·782	55·6	48·3	WNW
20	29·999	30·018	30·093	30·216	60·6	47·4	WNW	20	29·808	29·917	30·016	30·111	61·6	48·1	WNW
21	30·256	30·309	30·293	30·332	63·1	46·6	W	21	30·077	30·087	30·157	30·209	59·3	49·6	WNW
22	30·324	30·329	30·223	30·161	64·0	53·9	W	22	30·159	30·090	29·953	29·880	58·9	50·6	SW
23	30·013	29·985	29·985	30 049	64·2	53·4	NW	23	29·872	29·951	29·979	30·033	56·7	49·4	E
24	30·080	30·129	30·102	30·114	61·3	50·7	ENE	24	30·043	30·040	29·999	29·937	56·6	45·7	W
25	30·095	30·076	30·014	30·032	70·0	46·9	WSW	25	29·821	29·741	29·768	29·924	61·6	51·7	W
26	30·025	30·086	30·057	30·049	65·4	56·0	N	26	29·978	30·012	29·949	29 902	59·2	43·0	W
27	30·047	30·069	30·034	30·065	69·2	51·7	SW	27	29·860	29·896	29·924	29·968	58·1	48·9	W
28	30·073	30·035	29·944	29·934	73·1	48·6	SSE	28	29·936	29·842	29·639	29·621	59·0	47·1	S
29	29·918	29·954	29·939	30·027	73·1	49·1	SW	29	29·734	29·844	29·897	29·995	58·2	48·4	W
30	30·064	30·125	30·076	30·058	67·7	54·3	ENE	30	30·022	30·028	29·984	29·915	58·0	44·7	WSW
31	30·007	29·979	29·917	29·960	68·9	57·0	SW	31	29·841	29·818	29·785	29·887	58·3	46·4	W

SEPTEMBER, 1907.

KEW.								GLASGOW.							
	BAROMETER.				TEMPERATURE.				BAROMETER.				TEMPERATURE.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.
1	29·993	30·085	30·081	30·027	58·3	50·7	NW	1	29·941	29·984	29·923	29·788	55·8	39·5	W
2	29·900	29·734	29·567	29·539	61·9	51·1	S	2	29·532	29·362	29·300	29·466	57·2	49·2	SW
3	29·626	29·705	29·723	29·761	58·9	48·4	NW	3	29·608	29·657	29·690	29·735	51·2	37·2	W
4	29·696	29 937	29·985	29·976	58·7	46·4	N	4	29·746	29·803	29·793	29·677	55·8	38·4	W
5	29·827	29·867	29·886	29·964	67·3	50·5	WSW	5	29·523	29·544	29·562	29·634	60·1	46·9	WSW
6	29·992	30·028	30·039	30·122	71·0	60·4	SW	6	29·670	29·747	29·760	29·808	63·4	52·1	SW
7	30·158	30·224	30·237	30·287	68·1	56·0	S	7	29·917	30·025	30·111	30·226	61·4	51·3	W
8	30·315	30·392	30·379	30·438	72·0	55·3	ENE	8	30·311	30·398	30·399	30·423	60·4	44·0	W
9	30·427	30·443	30·379	30·379	69·3	54·6	E	9	30·405	30·391	30·314	30·297	69·1	48·1	NE
10	30·336	30·314	30·249	30·261	68·4	48·8	E	10	30·255	30·209	30·126	30·122	71·5	46·9	WSW
11	30·226	30·228	30·152	30·171	70·3	42·0	E	11	30·110	30·124	30·113	30·111	58·7	52·0	ENE
12	30·146	30·162	30·110	30·127	72·3	47·0	S	12	30·081	30·094	30·071	30·085	62·3	54·4	SW
13	30·103	30·102	30·015	30·037	72·7	48·6	S	13	30·075	30·050	29·982	29·924	57·8	52·3	W
14	30·059	30·124	30·139	30·237	64·4	52·3	NW	14	29·965	30·031	30·082	30·169	55·9	46·8	W
15	30·283	30·348	30·350	30·408	61·5	44·0	N	15	30·191	30·262	30·261	30·261	58·2	42·6	WSW
16	30·402	30·404	30·326	30·318	67·6	46·1	W	16	30·182	30·141	30·138	30·216	61·8	50·8	WSW
17	30·294	30·325	30·325	30·386	67·7	52·0	NNW	17	30·232	30·296	30·311	30·347	58·1	47·8	W
18	30·403	30·445	30·391	30·418	63·7	47·0	E	18	30·348	30·369	30·371	30·376	58·9	52·1	W
19	30·416	30·427	30·357	30·382	68·9	42·5	E	19	30·361	30·367	30·359	30·372	62·0	50·1	WSW
20	30·379	30·407	30·327	30·355	70·0	46·3	E	20	30·369	30·390	30·337	30·342	66·5	56·4	W
21	30·324	30·323	30·275	30·345	65·9	54·1	N	21	30·312	30·350	30·408	30·463	61·1	47·8	E
22	30·371	30·437	30·361	30·371	61·3	42·6	NE	22	30·442	30·416	30 289	30·231	54·3	46·3	NNE
23	30·304	30·286	30·158	30·140	62·4	37·0	E	23	30·137	30·089	30·018	29·969	60·6	53·7	SW
24	30·062	30·016	29·899	29 876	67·9	37·2	S	24	29·895	29·862	29·789	29·780	58·9	53·2	S
25	29·782	29·772	29·717	29·710	77·7	46·8	SE	25	29·733	29·719	29 643	29·635	61·8	46·8	E
26	29·682	29·682	29·642	29·654	70·3	58·1	SSW	26	29·604	29·629	29·601	29·647	64·9	53·1	ENE
27	29·632	29·660	29·677	29·749	72·5	58·1	ENE	27	29·700	29·791	29·812	29·885	61·9	53·4	E
28	29·757	29·802	29·787	29·827	71·7	58·3	ENE	28	29·880	29·905	29·871	29·893	62·2	51·0	ENE
29	29·778	29·790	29·761	29·773	62·7	55·6	NNE	29	29·867	29·877	29·822	29·829	60·3	48·7	ENE
30	29·745	29·738	29·690	29·680	62·7	57·1	NNE	30	29·783	29·758	29·660	29·621	52·3	48·4	S

OCTOBER, 1907.

1	29·619	29·565	29·450	29·452	65·1	54·2	S	1	29·519	29·447	29·299	29·203	59·5	49·1	E
2	29·488	29·546	29·550	29·553	61·8	48·0	SW	2	29·163	29·223	29·234	29·238	58·4	50·3	SSW
3	29·504	29·489	29·458	29·553	61·0	45·0	SW	3	29·255	29·388	29·486	29·654	55·7	48·1	SSE
4	29·667	29·820	29·898	30·017	61·0	42·6	N	4	29·749	29·863	29·910	29·953	58·8	40·9	W
5	30·059	30·078	30·014	29·967	60·6	44·2	W	5	29 860	29·778	29·743	29·742	58·1	47·4	SW
6	29·834	29·776	29·667	29·549	63·2	56·3	W	6	29·672	29·630	29·450	29·336	56·9	49·0	W
7	29·369	29·432	29·515	29·562	59·2	41·3	NW	7	29·336	29·372	29·378	29·410	49·2	41·1	W
8	29·501	29·482	29·506	29·582	50·9	41·6	NE	8	29·451	29·545	29·601	29·669	50·0	36·8	ENE
9	29·600	29·604	29·614	29·616	57·3	45·2	ESE	9	29·656	29·707	29·732	29·767	51·6	44·3	NE
10	29·615	29·662	29·693	29·763	61·0	46·9	SSE	10	29·591	29·589	29·630	29·617	57·2	49·6	SE
11	29·794	29·889	29·897	29·957	61·3	49·8	S	11	29·566	29·582	29·504	29·544	55·0	49·6	S
12	30·014	30·068	30·003	29·971	60·9	47·1	SW	12	29·576	29·672	29·685	29·639	53·8	48·4	WSW
13	29·828	29·749	29·699	29·655	60·9	42·0	W	13	29·578	29·546	29·468	29·383	53·3	47·0	SW
14	29·487	29·388	29·221	29·184	57·3	49·0	S	14	29·256	29·237	29·208	29·173	51·1	45·0	SW
15	29·184	29·231	29·360	29·410	55·5	40·7	SW	15	29·145	29·127	29·071	29·134	45·0	36·1	SW
16	29·372	29·308	29·148	29·079	54·0	39·1	E	16		29·392	29·434	29·534	47·3	37·9	W
17	29·066	29·129	29·145	29·148	52·7	49·3	SE	17	29·500	29·450	29·316	29·195	46·1	37·3	NE
18	29·253	29·305	29·259	29·318	56·1	45·4	S	18	29·122	29·041	28·903	28·908	52·8	41·0	ESE
19	29·421	29·577	29·649	29·708	60·0	50·7	SW	19	28·960	29·080	29·244	29·401	57·9	52·0	S
20	29·598	29·544	29 688	29·824	59·0	48·1	S	20	29·500	29·556	29·448	29·443	54·5	48·3	E
21	29·823	29·914	29·899	29·920	61·4	46·0	S	21	29·511	29·603	29·673	29·729	54·2	50·3	S
22	29·878	29·956	29·967	29·963	57·3	44·3	W	22	29·698	29·708	29·715	29·743	50·3	47·2	NE
23	29·871	29·893	29·876	29·894	53·3	36·7	SSW	23	29·738	29·791	29·804	29·805	49·1	45·9	E
24	29·858	29·876	29·878	29·914	53·3	36·0	SE	24	29·749	29·751	29·734	29·747	50·1	43·1	SSW
25	29·898	29·839	29·723	29·724	56·3	36·8	SSE	25	29·695	29·694	29·682	29·741	49·5	44·6	E
26	29·724	29·777	29·784	29·832	51·4	35·8	S	26	29·751	29·813	29·826	29 833	50·5	41·1	NE
27	29·820	29·821	29·774	29·748	49·1	37·4	W	27	29·804	29·782	29·703	29·694	48·1	33·1	W
28	29·644	29·576	29·501	29·446	56·7	37·3	SE	28	29·630	29·607	29·529	29·513	48·3	38·6	ENE
29	29·322	29·276	29·204	29·138	54·7	47·9	E	29	29·458	29·437	29·393	29·404	49·1	38·9	E
30	29·105	29·164	29·244	29·411	54·8	44·0	ESE	30	29·395	29·459	29·496	29 581	49·8	44·0	NE
31	29·546	29·716	29·803	29·914	56·0	39·7	SW	31	29·716	29·867	29·945	30·049	50·0	45·3	NE

NOVEMBER, 1907.

KEW.								GLASGOW.							
	Barometer.				Temperature.				Barometer.				Temperature.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.
1	29·957	29·976	29·878	29·830	54·4	36·6	NE	1	30·077	30·107	30·018	29·948	48·8	42·1	ENE
2	29·727	29·712	29·671	29·644	57·0	50·6	E	2	29·790	29·745	29·690	29·706	54·8	43·9	E
3	29·562	29·576	29·648	29·794	54·3	49·3	E	3	29·704	29·737	29·683	29·675	52·6	48·1	E
4	29·831	29·909	29·907	29·946	54·4	46·3	SE	4	29·719	29·836	29·884	29·949	56·1	49·3	SSW
5	29·977	30·059	30·072	30·139	54·8	47·1	N	5	29·958	30·023	30·107	30·208	52·2	43·0	W
6	30·161	30·185	30·137	30·145	52·6	44·6	N	6	30·243	30·295	30·271	30·256	47·5	40·2	W
7	30·072	30·068	30·010	29·952	49·3	46·1	NNE	7	30·197	30·152	30·018	29·948	43·8	36·1	SSE
8	29·877	29·809	29·737	29·745	55·7	46·4	ESE	8	29·838	29·794	29·721	29·675	49·0	40·1	S
9	29·743	29·787	29·801	29·884	59·6	43·1	SSE	9	29·599	29·629	29·709	29·823	48·1	44·0	W
10	29·930	30·021	30·032	30·088	51·8	36·8	SSE	10	29·883	29·983	29·963	29·904	46·7	38·1	W
11	30·064	30·020	29·906	29·857	42·5	35·9	W	11	29·767	29·685	29·632	29·654	50·0	43·9	SW
12	29·781	29·818	29·866	29·798	51·3	37·0	NW	12	29·634	29·616	29·348	29·218	47·9	41·4	WSW
13	29·662	29·769	29·916	30·078	53·2	41·2	W	13	29·220	29·615	29·829	29·905	49·0	42·6	WNW
14	30·110	30·139	30·086	30·090	52·9	38·0	SW	14	29·839	29·781	29·764	30·021	54·3	43·0	S
15	30·095	30·228	30·273	30·310	52·4	37·7	NNW	15	29·155	30·256	30·233	30·191	45·7	35·8	NNW
16	30·279	30·300	30·228	30·219	46·5	32·0	W	16	30·079	29·970	29·873	29·887	49·7	40·2	SW
17	30·179	30·173	30·130	30·145	52·2	44·0	SW	17	29·945	30·003	30·012	30·033	49·9	42·0	SW
18	30·156	30·249	30·290	30·335	49·0	44·4	NNE	18	29·171	30·320	30·346	30·343	44·2	34·0	W
19	30·296	30·273	30·204	30·204	49·1	37·6	WNW	19	29·203	30·072	29·949	29·921	47·2	32·1	S
20	30·186	30·208	30·205	30·274	44·0	39·9	WSW	20	30·012	30·106	30·121	30·161	47·1	37·1	SW
21	30·309	30·361	30·354	30·322	43·9	31·1	W	21	30·167	30·197	30·105	29·999	46·8	39·1	S
22	30·233	30·155	30·015	29·920	44·6	31·3	S	22	29·813	29·817	29·629	29·645	47·5	41·0	SSW
23	29·764	29·690	29·674	29·745	47·9	35·1	WSW	23	29·559	29·507	29·522	29·560	42·1	36·1	W
24	29·762	29·793	29·760	29·686	45·1	34·0	SW	24	29·517	29·538	29·518	29·461	40·3	31·4	W
25	29·415	29·477	29·512	29·497	47·0	32·4	N	25	29·416	29·435	29·419	29·420	36·4	26·3	SW
26	29·358	29·218	29·109	29·267	55·2	34·2	S	26	29·310	29·162	28·859	28·911	40·1	27·8	E
27	29·220	29·356	29·468	29·574	51·6	45·4	SW	27	28·975	29·083	29·207	29·339	41·4	36·6	NE
28	29·624	29·710	29·749	29·866	53·2	44·2	S	28	29·459	29·631	29·765	29·969	42·4	36·3	E
29	29·974	30·163	30·239	30·351	45·5	34·7	N	29	30·099	30·256	30·339	30·370	37·4	30·1	WNW
30	30·377	30·439	30·378	30·355	45·9	32·7	NNE	30	30·393	30·424	30·406	30·378	36·8	31·0	NNE

DECEMBER, 1907.

1	30·240	30·131	29·997	29·933	44·9	39·4	E	1	30·274	30·189	29·941	29·839	40·5	26·3	E
2	29·909	29·878	29·736	29·556	51·5	39·2	S	2	29·696	29·592	29·407	29·158	46·3	38·0	ESE
3	29·318	29·395	29·473	29·486	52·1	37·7	W	3	29·038	29·124	29·111	29·122	48·0	34·1	SW
4	29·503	29·438	29·233	29·175	51·0	34·9	S	4	29·086	28·950	28·686	28·652	44·0	33·9	SSE
5	28·954	29·131	29·264	29·400	50·7	37·9	WSW	5	28·732	28·820	28·920	29·065	40·6	36·1	WSW
6	29·500	29·632	29·697	29·746	44·0	31·0	SW	6	29·242	29·402	29·430	29·388	41·8	36·5	WSW
7	29·674	29·693	29·677	29·411	48·9	33·2	SW	7	29·392	29·478	29·371	29·113	40·1	34·0	W
8	29·201	29·167	29·100	29·156	56·6	48·6	SW	8	28·871	28·753	28·666	28·663	47·1	33·6	N
9	29·269	29·471	29·507	29·419	50·5	46·2	WSW	9	28·769	28·915	28·981	28·971	47·0	40·7	SW
10	29·344	29·424	29·428	29·512	49·3	43·0	SW	10	28·898	28·857	28·917	28·991	47·0	39·2	WSW
11	29·502	29·530	29·559	29·563	47·3	38·7	SW	11	29·009	29·097	29·204	29·282	45·1	41·9	WSW
12	29·394	29·334	29·270	29·394	46·2	38·0	S	12	29·301	29·344	29·344	29·364	43·1	36·2	WSW
13	29·447	29·461	29·164	28·764	50·0	37·0	SSW	13	29·266	29·028	28·678	28·613	42·9	35·9	SSW
14	28·762	28·796	29·127	29·463	44·1	38·8	WNW	14	28·751	29·046	29·321	29·548	43·2	34·8	NW
15	29·671	29·897	30·041	30·152	40·3	30·4	W	15	29·723	29·865	29·935	29·969	38·5	29·9	ENE
16	30·195	30·251	30·255	30·278	46·9	30·3	SSE	16	29·969	29·959	29·937	29·941	46·8	34·2	SE
17	30·300	30·320	30·274	30·241	45·4	34·4	SE	17	29·955	29·999	30·004	30·003	50·2	43·7	S
18	30·149	30·122	30·048	30·033	51·1	32·0	S	18	29·858	29·765	29·794	29·780	47·1	42·2	WSW
19	29·984	29·966	29·938	29·942	54·0	50·7	SW	19	29·699	29·692	29·720	29·768	48·8	43·0	SW
20	29·901	29·904	29·850	29·784	54·2	49·8	SSW	20	29·750	29·690	29·592	29·506	44·1	37·9	E
21	29·717	29·726	29·811	29·900	52·0	45·8	SW	21	29·402	29·470	29·536	29·602	45·5	40·6	NW
22	29·923	29·970	29·970	30·008	52·3	44·5	S	22	29·567	29·596	29·746	29·866	48·1	41·7	W
23	30·043	30·130	30·169	30·263	48·9	38·9	NNE	23	29·944	30·033	30·109	30·189	44·6	40·4	W
24	30·288	30·321	30·264	30·246	44·0	39·1	ENE	24	30·239	30·274	30·243	30·232	42·3	34·7	E
25	30·179	30·148	30·094	30·065	43·7	37·8	E	25	30·193	30·191	30·130	30·096	42·6	33·9	E
26	30·023	30·008	29·893	29·831	39·0	35·0	E	26	30·049	29·994	29·933	29·909	39·5	35·0	E
27	29·754	29·687	29·612	29·597	36·0	33·9	E	27	29·841	29·798	29·754	29·750	38·1	33·3	E
28	29·559	29·608	29·636	29·730	36·2	33·6	ENE	28	29·751	29·826	29·865	29·952	36·1	33·4	E
29	29·801	29·927	29·972	29·992	35·6	33·9	NNE	29	29·994	30·072	30·090	30·110	36·4	33·6	NE
30	29·973	29·989	29·944	29·936	35·5	33·7	NE	30	30·134	30·162	30·128	30·122	35·9	30·4	ENE
31	29·898	29·882	29·831	29·873	37·1	34·9	NE	31	30·067	30·046	30·008	30·062	37·1	33·5	ENE

TABLE VII.—BAROMETER, THERMOMETER, ETC., READINGS, 1908.

JANUARY, 1908.

KEW.								GLASGOW.							
	BAROMETER.				TEMPERATURE.				BAROMETER.				TEMPERATURE.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.
1	29·908	30·027	30·094	30·222	37·1	33·6	NE	1	30·149	30·244	30·327	30·407	38·7	34·5	E
2	30·282	30·342	30·341	30·328	34·1	28·7	ENE	2	30·444	30·496	30·458	30·448	37·1	27·2	E
3	30·275	30·267	30·212	30·218	32·5	24·9	ENE	3	30·417	30·436	30·393	30·388	29·1	23·1	SSE
4	30·218	30·266	30·245	30·297	37·9	27·6	NE	4	30·342	30·349	30·254	30·248	28·3	20·7	SSE
5	30·310	30·373	30·397	30·404	29·6	19·4	NE	5	30·216	30·209	30·119	29·968	38·6	22·1	SSE
6	30·264	30·084	29·902	29·864	47·9	20·4	SSW	6	30·622	29·510	29·532	29·574	50·1	37·9	W
7	29·760	29·593	29·342	29·039	49·6	43·9	S	7	29·518	29·396	29·218	29·112	42·1	35·2	E
8	28·918	28·978	29·116	29·324	42·0	33·9	WNW	8	29·166	29·383	29·620	29·744	37·9	35·1	NNE
9	29·526	29·672	29·778	29·970	38·1	30·7	N	9	29·836	29·958	30·052	30·174	37·1	32·9	NE
10	30·118	30·280	30·335	30·428	36·0	26·2	N	10	30·231	30·262	30·213	30·186	37·9	26·9	NNE
11	30·454	30·474	30·431	30·400	33·0	21·7	WSW	11	30·129	30·101	30·074	30·071	40·2	36·1	SW
12	30·357	30·339	30·243	30·222	35·0	20·9	ESE	12	30·075	30·109	30·079	30·051	40·2	32·1	SW
13	30·183	30·208	30·202	30·224	39·9	23·5	NE	13	29·986	29·984	29·998	30·034	40·9	29·2	SE
14	30·225	30·274	30·252	30·248	45·0	31·0	S	14	30·024	30·032	29·941	29·896	46·8	38·2	S
15	30·205	30·209	30·123	30·086	46·3	34·0	SSW	15	29·761	29·751	29·673	29·466	47·0	43·5	SW
16	30·004	29·983	29·969	30·014	50·5	45·6	SW	16	29·374	29·504	29·617	29·621	50·4	43·4	SW
17	30·009	30·027	30·006	30·081	52·1	48·4	SSW	17	29·540	29·477	29·440	29·615	52·0	44·8	SW
18	30·209	30·330	30·325	30·336	49·6	30·9	SW	18	29·895	30·121	30·186	30·190	46·7	37·9	W
19	30·322	30·305	30·235	30·281	39·3	31·2	SW	19	30·118	30·076	30·002	30·120	44·1	37·0	SW
20	30·325	30·472	30·510	30·595	43·5	29·4	N	20	30·244	30·321	30·356	30·348	43·2	35·2	SW
21	30·584	30·600	30·530	30·489	34·0	27·1	N	21	30·333	30·356	30·340	30·327	44·4	38·0	WSW
22	30·446	30·437	30·403	30·450	40·0	31·3	SE	22	30·298	30·276	30·206	30·182	41·7	36·0	S
23	30·458	30·487	30·465	30·489	37·9	32·9	E	23	30·155	30·200	30·246	30·361	47·1	38·6	SSW
24	30·481	30·489	30·448	30·420	37·3	33·0	E	24	30·378	30·410	30·332	30·268	46·4	41·0	ESE
25	30·378	30·382	30·362	30·357	42·0	31·2	SW	25	30·102	29·998	29·918	29·988	45·2	35·6	SW
26	30·328	30·258	30·050	30·022	50·3	42·0	SW	26	29·912	29·600	29·652	29·738	48·7	37·9	WSW
27	29·979	29·890	29·832	29·836	53·9	45·8	WSW	27	29·543	29·479	29·446	29·374	49·3	38·3	W
28	29·754	29·628	29·383	29·367	46·6	38·8	SW	28	29·264	29·150	29·205	29·586	40·4	33 7	SW
29	29·607	29·839	29·912	30·058	42·6	34·6	NW	29	29·719	29·823	29·981	30·122	38·4	33·1	N
30	30·139	30·183	30·061	29·993	40·1	34·0	W	30	30·051	29·871	29·781	29·778	44·7	31·2	W
31	29·957	29·936	29·809	29·787	46·1	36·9	W	31	29·677	29·601	29·605	29·713	42·8	35·6	WNW

FEBRUARY, 1908.

1	29·840	29·905	29·989	30·124	43·6	35·0	NNW	1	29·789	29·953	30·084	30·178	39·0	32·6	WNW
2	30·210	30·304	30·320	30·347	42·0	30·9	N	2	30·192	30·235	30·222	30·133	45·2	35·1	W
3	30·274	30·165	30·076	30·138	45·5	33·1	SW	3	29·885	29·938	30·046	30·271	44·8	35·4	WNW
4	30·242	30·404	30·466	30·556	42·9	35·7	N	4	30·394	30·504	30·522	30·527	43·1	33·1	WNW
5	30·607	30·632	30·594	30·604	43·4	32·5	NNW	5	30·497	30·466	30·427	30·476	49·0	40·6	W
6	30·597	30·670	30·651	30·712	50·3	35·8	SW	6	30·528	30·570	30·584	30·619	49·1	40·7	WSW
7	30·703	30·695	30·610	30·591	48·1	35·4	SW	7	30·580	30·524	30·472	30·416	48·6	40·0	W
8	30·504	30·451	30·398	30·402	47·0	37·0	W	8	30·314	30·274	30·278	30·304	50·2	43·9	WNW
9	30·388	30·444	30·453	30·460	48·3	38·0	NW	9	30·316	30·356	30·328	30·286	48·1	43·1	W
10	30·437	30·488	30·480	30·543	49·5	37·3	NW	10	30·251	30·313	30·317	30·330	48·1	43·5	W
11	30·542	30·565	30·496	30·516	49·1	34·7	SSW	11	30·297	30·299	30·272	30·301	47·1	43·9	W
12	30·486	30·479	30·409	30·369	49·7	37·3	S	12	30·290	30·309	30·285	30·262	47·1	43·0	SW
13	30·293	30·230	30·151	30·151	45·0	31·3	ESE	13	30·151	30·144	30·009	29·972	43·8	35·3	ENE
14	30·125	30·188	30·236	30·319	50·6	38·9	SW	14	29·907	29·937	29·944	29·757	47·0	40·3	W
15	30·206	30·070	29·829	30·021	49·5	38·0	SW	15	29·696	29·733	29·740	29·762	44·3	36·4	W
16	30·061	30·126	30·169	30·197	47·8	34·4	WNW	16	29·764	29·952	30·006	29·903	43·7	36·9	WNW
17	29·906	29·550	29·452	29·620	53·5	38·2	SW	17	29·608	29·459	29·456	29·552	44·3	34·1	ENE
18	29·708	29·599	29·613	29·778	52·6	43·6	W	18	29·351	29·360	29·571	29·694	48·1	36·5	NW
19	29·839	29·843	29·849	29·904	52·4	41·3	WNW	19	29·670	29·710	29·708	29·762	47·4	35·4	W
20	29·913	29·969	29·911	29·920	51·7	43·6	SW	20	29·657	29·734	29·711	29·710	49·1	42·1	W
21	29·921	29·897	29·825	29·883	52·1	44·0	WSW	21	29·599	29·464	29·408	29·428	47·9	39·3	W
22	29·894	29·801	29·451	29·666	50·6	42·8	SW	22	29·374	28·908	28·980	29·108	48·1	36·1	SW
23	29·721	29·740	29·671	29·699	49·1	40·0	WSW	23	29·299	29·365	29·371	29·353	42·8	34·3	W
24	29·626	29·645	29·657	29·825	46·1	36·9	WNW	24	29·316	29·516	29·739	29·865	48·8	34·1	NW
25	29·894	29·912	29·758	29·922	47·4	39·0	W	25	29·860	29·738	29·817	29·971	47·0	39·0	NW
26	30·043	30·093	29·916	29·822	47·9	37·4	W	26	29·960	29·712	29·584	29·590	48·9	38·1	SW
27	29·804	29·744	29·614	29·614	47·0	37·5	W	27	29·415	29·304	29·225	29·171	40·0	29·9	W
28	29·499	29·259	29·177	29·169	43·1	33·7	W	28	28·960	28·833	28·854	29·013	34·8	29·4	WNW
29	29·067	29·207	29·257	29·269	41·0	32·0	NW	29	29·130	29·298	29·376	29·451	39·3	30·5	NNW

MARCH, 1908.

KEW.								GLASGOW.							
	Barometer.				Temperature.		Direction of wind at noon.		Barometer.				Temperature.		Direction of wind at noon.
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.		Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	
1	29·293	29·331	29·329	29·445	40·9	33·8	NNW	1	29·504	29·578	29·672	29·736	40·9	35·3	N
2	29·564	29·648	29·641	29·655	43·3	34·3	N	2	29·704	29·719	29·685	29·727	43·1	35·1	N
3	29·607	29·629	29·603	29·570	40·9	33·2	W	3	29·716	29·717	29·698	29·721	41·6	35·3	NNE
4	29·555	29·622	29·674	29·788	41·9	33·7	NE	4	29·730	29·768	29·766	29·806	41·0	32·3	E
5	29·890	29·982	29·961	29·859	43·9	33·2	WSW	5	29·815	29·790	29·678	29·537	39·1	28·5	S
6	29·510	29·192	29·143	29·359	49·6	39·0	SW	6	29·366	29·341	29·424	29·529	39·5	35·3	ENE
7	29·581	29·770	29·778	29·811	46·0	39·7	W	7	29·553	29·583	29·603	29·629	44·3	33·4	NW
8	29·810	29·740	29·660	29·490	54·2	39·7	W	8	29·507	29·425	29·071	28·693	49·3	38·2	SW
9	29·377	29·413	29·369	29·284	49·6	39·6	WSW	9	28·669	28·721	28·719	28·807	47·1	38·0	W
10	29·234	29·326	29·386	29·442	47·5	40·6	W	10	28·977	29·137	29·351	29·536	46·6	40·6	NNW
11	29·549	29·752	29·825	29·901	46·6	34·4	N	11	29·671	29·765	29·794	29·860	46·9	33·7	WNW
12	29·948	30·017	29·994	30·018	47·0	28·8	N	12	29·910	29·968	29·974	30·017	45·3	28·8	NE
13	30·031	30·091	30·116	30·168	44·3	33·9	N	13	30·025	30·061	30·040	30·052	44·2	30·2	W
14	30·161	30·198	30·168	30·222	41·6	31·0	E	14	30·065	30·125	30·135	30·169	45·7	35·8	ENE
15	30·214	30·210	30·134	30·122	37·9	27·4	E	15	30·137	30·097	29·994	29·945	41·4	34·1	S
16	30·014	29·957	29·917	29·934	45·5	33·3	SW	16	29·881	29·931	29·919	29·915	42·5	35·3	ENE
17	29·892	29·866	29·812	29·870	43·4	33·4	NW	17	29·843	29·839	29·826	29·907	43·1	36·5	E
18	29·851	29·863	29·838	29·900	42·3	34·0	N	18	29·902	29·909	29·906	29·992	42·0	35·9	W
19	29·882	29·882	29·825	29·865	41·0	31·4	NE	19	29·899	29·997	29·937	29·944	39·5	30·9	E
20	29·845	29·852	29·815	29·890	42·3	28·2	N	20	29·892	29·880	29·804	29·836	41·3	30·2	S
21	29·910	29·973	29·954	29·942	46·1	34·3	SW	21	29·834	29·851	29·802	29·745	42·8	31·1	S
22	29·782	29·605	29·481	29·518	47·4	34·4	SSE	22	29·568	29·386	29·241	29·315	43·0	33·2	ESE
23	29·640	29·822	29·916	30·025	55·0	40·3	W	23	29·442	29·631	29·757	29·843	52·3	41·4	SW
24	30·062	30·090	30·043	30·058	56·6	32·6	SW	24	29·841	29·874	29·908	29·955	45·5	42·5	S
25	29·992	29·954	29·892	29·930	47·0	41·1	E	25	29·943	29·941	29·937	29·961	45·0	38·4	E
26	29·943	30·017	30·062	30·136	45·5	40·4	N	26	29·956	30·010	30·004	30·024	44·2	38·2	E
27	30·138	30·140	30·004	29·977	52·5	40·2	SW	27	29·951	29·776	29·644	29·743	46·2	37·8	S
28	29·868	29·971	30·069	30·156	49·9	39·6	NW	28	29·788	29·821	29·720	29·648	47·6	34·1	SW
29	30·128	30·089	29·948	29·878	52·2	37·0	SW	29	29·578	29·440	29·457	29·549	47·9	36·2	SSW
30	29·918	29·962	29·841	29·578	53·1	38·7	SW	30	29·563	29·552	29·238	28·927	46·9	34·6	SW
31	29·608	29·711	29·765	29·771	49·1	38·2	W	31	29·097	29·314	29·412	29·526	44·2	36·8	WNW

APRIL, 1908.

1	29·807	29·926	29·961	30·023	51·5	36·8	W	1	29·618	29·748	29·787	29·817	47·8	35·1	W
2	29·998	30·011	29·926	29·883	58·2	44·2	W	2	29·729	29·645	29·579	29·508	50·5	41·9	SW
3	29·872	29·857	29·832	29·894	53·3	42·6	W	3	29·381	29·457	29·566	29·662	48·2	41·1	WNW
4	29·871	29·880	29·822	29·887	51·0	39·4	NW	4	29·727	29·842	29·883	30·001	48·5	39·3	NW
5	29·854	29·873	29·898	30·061	46·2	40·0	N	5	30·047	30·114	30·185	30·289	46·8	38·1	N
6	30·127	30·210	30·239	30·356	49·0	39·8	NNE	6	30·327	30·380	30·381	30·405	48·5	32·4	NE
7	30·339	30·328	30·257	30·286	52·4	37·1	N	7	30·413	30·393	30·294	30·263	51·9	31·7	SW
8	30·241	30·210	30·112	30·121	55·4	33·8	NNE	8	30·205	30·164	30·102	30·070	49·1	43·9	WSW
9	30·083	30·055	29·950	29·938	58·5	28·0	SE	9	30·006	29·986	29·955	29·991	51·8	43·7	WNW
10	29·915	29·936	29·905	29·890	48·6	43·0	N	10	29·955	29·901	29·815	29·781	48·7	36·2	WSW
11	29·823	29·814	29·809	29·875	46·7	42·2	E	11	29·743	29·770	29·809	29·930	45·7	42·2	SE
12	29·910	29·979	30·018	30·130	51·8	39·6	NE	12	30·026	30·096	30·104	30·140	46·1	35·8	E
13	30·134	30·136	30·105	30·163	46·7	36·5	ENE	13	30·146	30·180	30·211	30·325	46·1	38·6	E
14	30·156	30·163	30·138	30·178	47·3	35·4	N	14	30·355	30·399	30·359	30·389	50·0	36·1	ENE
15	30·146	30·184	30·107	30·130	54·9	37·2	NE	15	30·372	30·387	30·391	30·460	44·3	36·9	NE
16	30·140	30·219	30·209	30·242	57·7	40·1	NE	16	30·511	30·539	30·510	30·505	50·2	37·6	ENE
17	30·224	30·204	30·088	30·029	54·7	38·6	NNE	17	30·460	30·361	30·131	30·071	61·6	36·1	WNW
18	29·876	29·902	29·863	29·861	49·0	38·0	NNE	18	30·117	30·119	30·031	29·999	50·9	39·2	NNE
19	29·775	29·703	29·640	29·692	45·0	34·0	NNW	19	29·902	29·850	29·826	29·884	48·5	34·9	N
20	29·666	29·763	29·811	29·884	44·0	33·4	N	20	29·886	29·890	29·802	29·763	48·4	36·2	NW
21	29·824	29·792	29·773	29·792	49·8	32·1	WNW	21	29·715	29·745	29·719	29·721	49·1	38·8	NNE
22	29·751	29·723	29·638	29·606	52·6	40·4	SW	22	29·659	29·659	29·659	29·711	44·2	35·1	NE
23	29·623	29·655	29·535	29·430	44·0	33·0	E	23	29·724	29·709	29·589	29·571	39·2	28·0	NW
24	29·355	29·409	29·441	29·481	42·3	31·9	NW	24	29·451	29·433	29·401	29·398	37·9	22·8	ENE
25	29·450	29·374	29·258	29·415	44·8	33·3	SE	25	29·350	29·348	29·393	29·542	43·7	24·4	S
26	29·502	29·569	29·627	29·706	50·1	33·7	W	26	29·547	29·559	29·547	29·565	47·4	33·2	NE
27	29·715	29·759	29·773	29·781	51·2	37·4	S	27	29·605	29·674	29·696	29·714	49·1	35·1	E
28	29·723	29·655	29·623	29·717	48·4	43·9	E	28	29·694	29·707	29·699	29·786	48·0	37·3	E
29	29·837	29·989	30·048	30·145	62·4	45·0	NW	29	29·855	29·936	29·985	30·008	46·0	39·6	E
30	30·166	30·187	30·158	30·160	58·6	48·9	S	30	29·971	29·924	29·896	29·963	52·2	42·9	E

MAY, 1908.

Date.	KEW. Barometer. 4 A.M.	10 A.M.	4 P.M.	10 P.M.	Temperature. Max	Min.	Direction of wind at noon.	Date.	GLASGOW. Barometer. 4 A.M.	10 A.M.	4 P.M.	10 P.M.	Temperature. Max	Min.	Direction of wind at noon.
1	30·143	30·167	30·111	30·103	74·1	53·7	N	1	30·000	30·061	30·076	30·086	58·4	47·4	SW
2	30·073	30·058	29·989	30·010	74·4	56·8	W	2	30·057	30·080	30·096	30·101	55·3	42·6	E
3	29·975	29·985	29·948	29·918	57·2	49·7	E	3	30·055	30·009	29·914	29·846	44·7	41·3	ENE
4	29·820	29·728	29·640	29·630	61·0	49·9	SSW	4	29·748	29·650	29·526	29·446	48·9	41·1	E
5	29·587	29·525	29·436	29·418	58·1	48·9	S	5	29·368	29·305	29·194	29·159	57·0	43·4	SE
6	29·371	29·378	29·432	29·630	59·3	48·4	SW	6	29·140	29·176	29·216	29·375	59·1	47·9	SW
7	29·747	29·875	29·915	29·916	62·0	45·0	W	7	29·496	29·604	29·658	29·612	53·0	40·5	WSW
8	29·838	29·854	29·837	29·765	58·3	53·0	SW	8	29·521	29·516	29·432	29·362	56·1	46·0	SW
9	29·709	29·779	29·795	29·855	65·3	49·6	W	9	29·397	29·541	29·596	29·585	55·6	48·2	WSW
10	29·853	29·878	29·865	29·960	63·1	47·9	W	10	29·574	29·626	29·638	29·674	56·1	43·3	SSW
11	29·984	29·961	29·872	29·832	60·6	43·3	SE	11	29·738	29·792	29·780	29·800	60·5	47·1	SW
12	29·778	29·788	29·754	29·757	63·5	47·9	W	12	29·734	29·729	29·688	29·702	51·8	45·3	NE
13	29·750	29·738	29·700	29·705	59·0	45·1	SW	13	29·682	29·662	29·576	29·571	52·8	44·1	ENE
14	29·653	29·631	29·579	29·627	54·7	43·6	SSE	14	29·551	29·551	29·520	29·542	57·1	42·5	ENE
15	29·645	29·685	29·673	29·830	55·1	45·9	SSW	15	29·506	29·560	29·642	29·786	56·2	45·9	ENE
16	30·066	30·163	30·238	30·327	62·2	46·0	WSW	16	29·869	29·940	29·986	30·048	58·2	44·0	SW
17	30·349	30·401	30·397	30·423	72·7	55·5	SW	17	29·966	30·082	30·123	30·092	59·5	50·3	W
18	30·437	30·458	30·401	30·400	70·0	52·2	W	18	30·104	30·185	30·236	30·269	59·5	50·5	W
19	30·371	30·348	30·226	30·242	73·1	52·3	W	19	30·247	30·211	30·166	30·180	57·3	46·8	NW
20	30·276	30·305	30·214	30·136	64·7	51·9	E	20	30·206	30·231	30·124	29·984	56·6	44·9	SW
21	29·936	29·835	29·751	29·794	64·8	45·9	W	21	29·815	29·750	29·630	29·599	55·2	43·2	W
22	29·764	29·732	29·792	29·896	58·7	44·4	WSW	22	29·593	29·672	29·732	29·864	57·1	40·9	W
23	29·973	30·044	30·028	30·077	61·0	41·6	NNE	23	29·932	29·980	29·967	29·948	55·9	40·3	SW
24	30·017	29·969	29·881	29·863	62·8	42·0	S	24	29·835	29·723	29·586	29·533	56·9	44·9	S
25	29·803	29·838	29·874	29·949	59·6	50·2	WSW	25	29·499	29·568	29·663	29·790	54·3	41·7	SW
26	30·026	30·132	30·213	30·320	52·2	51·8	WSW	26	29·866	29·961	30·119	30·225	58·2	43·1	W
27	30·404	30·460	30·435	30·495	72·0	48·9	NE	27	30·306	30·437	30·465	30·491	66·1	52·3	W
28	30·480	30·440	30·352	30·383	68·6	48·8	NE	28	30·479	30·457	30·409	30·410	75·8	49·4	N
29	30·349	30·272	30·146	30·097	70·0	50·9	NE	29	30·407	30·401	30·306	30·300	69·1	49·0	E
30	29·995	29·979	29·930	29·927	67·4	53·6	ENE	30	30·290	30·216	30·118	30·058	68·0	46·3	E
31	29·915	29·94_	29·896	29·915	76·0	54·8	SE	31	29·966	29·915	29·858	29·895	71·8	52·7	E

JUNE, 1908.

1	29·881	29·878	29·867	29·925	76·9	60·0	S	1	29·919	29·931	29·891	29·908	61·8	51·5	ENE
2	29·858	29·925	29·951	29·995	71·7	56·4	SSW	2	29·926	29·931	29·883	29·914	54·3	51·1	E
3	30·009	30·022	30·009	30·027	77·1	54·0	E	3	29·956	30·025	30·013	30·012	70·9	51·5	SW
4	30·017	30·011	29·932	29·997	79·3	57·9	N	4	29·998	30·029	30·040	30·048	63·4	46·9	WNW
5	29·985	30·011	29·949	29·933	65·1	53·6	N	5	30·037	29·982	29·912	29·877	55·6	44·8	W
6	29·863	29·941	30·015	30·108	56·9	48·0	N	6	29·965	30·053	30·061	30·074	62·5	46·0	N
7	30·136	30·186	30·108	30·088	64·1	41·1	NW	7	30·061	30·041	29·971	29·947	53·1	45·2	W
8	30·087	30·076	30·044	30·158	66·9	50·2	W	8	29·937	29·949	29·959	30·021	55·0	45·2	W
9	30·179	30·208	30·204	30·248	69·1	48·6	W	9	30·022	30·017	30·096	30·149	59·8	47·0	W
10	30·262	30·280	30·234	30·233	74·6	55·3	W	10	30·143	30·116	30·045	29·972	60·3	53·1	SW
11	30·223	30·201	30·098	30·079	70·9	54·1	SSW	11	29·900	29·825	29·804	29·884	56·9	47·5	W
12	30·031	29·995	29·937	29·950	65·0	53·9	W	12	29·884	29·882	29·824	29·771	57·4	43·2	SW
13	29·931	29·900	29·796	29·699	62·9	50·8	SW	13	29·641	29·441	29·296	29·298	55·1	48·7	SW
14	29·626	29·734	29·833	29·969	66·4	50·9	WSW	14	29·412	29·649	29·764	29·820	58·6	45·1	WNW
15	29·979	29·932	29·826	29·783	67·3	45·9	SSW	15	29·782	29·638	29·456	29·422	54·7	44·8	S
16	29·708	29·695	29·687	29·704	65·5	53·6	SW	16	29·434	29·522	29·621	29·722	59·1	48·3	SW
17	29·670	29·699	29·733	29·824	61·5	52·8	WNW	17	29·796	29·864	29·872	29·897	57·5	46·5	E
18	29·885	29·939	29·914	29·917	68·1	46·9	WSW	18	29·877	29·864	29·802	29·756	50·6	45·3	NE
19	29·858	29·788	29·742	29·791	70·0	47·6	NW	19	29·682	29·699	29·624	29·742	57·5	47·0	SW
20	29·833	29·886	29·947	30·079	63·4	48·4	NE	20	29·843	29·962	30·005	30·099	64·1	45·2	NE
21	30·117	30·164	30·128	30·157	62·7	50·3	NE	21	30·122	30·145	30·104	30·095	69·1	45·2	WSW
22	30·141	30·146	30·090	30·127	68·3	45·1	NE	22	30·066	30·030	29·987	30·049	69·8	48·1	SSW
23	30·120	30·135	30·122	30·183	71·8	45·7	N	23	30·089	30·141	30·154	30·241	63·2	48·3	W
24	30·223	30·251	30·235	30·313	71·6	51·3	ENE	24	30·287	30·335	30·316	30·322	66·9	47·4	E
25	30·314	30·322	30·252	30·294	70·1	51·0	ENE	25	30·316	30·309	30·287	30·292	68·5	50·1	WNW
26	30·297	30·317	30·291	30·331	76·2	46·4	NE	26	30·313	30·341	30·327	30·358	76·1	56·0	NE
27	30·362	30·361	30·326	30·318	68·0	52·9	NE	27	30·378	30·377	30·324	30·319	79·4	59·8	NW
28	30·300	30·292	30·218	30·226	74·3	55·7	E	28	30·327	30·308	30·255	30·268	71·8	57·8	NE
29	30·222	30·213	30·156	30·206	75·6	55·7	E	29	30·271	30·248	30·216	30·255	70·0	54·9	E
30	30·189	30·196	30·158	30·242	76·9	53·0	E	30	30·263	30·254	30·230	30·280	71·5	52·1	ENE

JULY, 1908.

KEW.								GLASGOW.							
	Barometer.				Temperature.		Direction of wind at noon.		Barometer.				Temperature.		Direction of wind at noon.
Date	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.		Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min	
1	30·246	30·260	30·239	30·281	78·9	55·1	NE	1	30·309	30·317	30·275	30·299	77·2	52·1	NNE
2	30·296	30·291	30·241	30·246	79·7	54·7	NE	2	30·307	30·302	30·248	30·265	8·8	55·5	W
3	30·225	30·178	30·080	30·110	81·2	52·4	NE	3	30·246	30·211	30·122	30·123	77·6	56·8	ENE
4	30·053	30·059	29·995	30·007	65·7	57·7	E	4	30·051	30·027	29·982	29·996	69·2	55·0	ENE
5	30·004	30·036	30·015	30·037	68·3	56·7	SE	5	29·988	30·002	30·010	30·003	61·7	54·4	ENE
6	30·020	30·015	29·943	29·938	72·7	56·2	W	6	29·996	29·981	29·934	29·909	60·4	50·3	E
7	29·926	29·916	29·865	29·920	71·0	56·3	W	7	29·868	29·834	29·810	29·813	63·1	48·2	SW
8	29·891	29·838	29·740	29·714	64·8	56·7	SSW	8	29·765	29·677	29·579	29·547	59·9	48·5	SE
9	29·748	29·823	29·847	29·890	69·2	54·7	W	9	29·575	29·649	29·677	29·680	60·8	49·6	E
10	29·786	29·785	29·762	29·753	67·4	55·1	SW	10	29·610	29·469	29·373	29·342	62·8	51·8	SSE
11	29·739	29·733	29·667	29·625	71·2	58·5	SSW	11	29·359	29·416	29·408	29·384	60·3	54·6	SW
12	29·633	29·619	29·563	29·541	68·5	56·8	NE	12	29·387	29·444	29·489	29·553	63·9	53·9	SW
13	29·522	29·575	29·634	29·698	61·3	56·0	W	13	29·571	29·611	29·634	29·683	59·6	51·8	NE
14	29·731	29·761	29·789	29·848	64·0	51·8	SW	14	29·685	29·707	29·708	29·752	63·4	51·1	W
15	29·873	29·909	29·926	29·938	66·8	53·1	SW	15	29·750	29·750	29·718	29·616	58·2	46·9	WSW
16	29·852	29·818	29·676	29·552	64·6	55·9	SW	16	29·591	29·549	29·308	29·162	57·7	52·2	SSE
17	29·466	29·393	29·365	29·439	63·9	57·3	SW	17	29·141	29·184	29·310	29·510	62·7	54·6	NW
18	29·479	29·632	29·751	29·913	64·5	55·8	NW	18	29·642	29·794	29·912	30·021	67·0	54·4	N
19	29·987	30·068	30·097	30·122	63·5	55·0	N	19	30·096	30·119	30·097	30·091	65·4	47·9	WSW
20	30·075	30·086	30·104	30·185	67·3	49·7	N	20	30·083	30·112	30·117	30·143	64·1	52·0	W
21	30·194	30·221	30·172	30·181	71·1	52·9	W	21	30·147	30·135	30·083	30·047	69·4	48·1	SW
22	30·155	30·133	30·069	30·086	76·1	50·3	SW	22	30·005	29·976	29·925	29·917	65·9	53·1	SW
23	30·079	30·086	30·063	30·084	75·4	54·6	W	23	29·914	29·953	29·962	29·974	63·9	52·1	SW
24	30·068	30·063	30·007	30·002	78·6	55·4	SW	24	29·972	29·947	29·885	29·808	63·9	54·6	S
25	29·957	29·929	29·940	30·023	76·4	59·3	S	25	29·733	29·768	29·807	29·900	64·4	56·5	SSW
26	30·061	30·116	30·094	30·126	76·1	55·3	S	26	29·971	30·028	30·040	30·037	61·6	49·2	SW
27	30·120	30·131	30·101	30·132	75·2	54·4	NW	27	30·010	29·989	29·976	30·035	68·4	52·6	SSW
28	30·143	30·177	30·215	30·335	72·9	57·5	NW	28	30·073	30·157	30·265	30·349	60·9	54·0	W
29	30·384	30·416	30·389	30·399	72·9	53·9	N	29	30·364	30·368	30·296	30·229	67·1	48·2	SW
30	30·392	30·348	30·259	30·243	80·5	52·3	W	30	30·166	30·186	30·163	30·157	62·3	54·0	WSW
31	30·220	30·248	30·233	30·287	71·6	57·0	NNW	31	30·153	30·192	30·209	30·224	60·1	51·3	W

AUGUST, 1908.

1	30·286	30·278	30·233	30·259	69·2	49·0	NNW	1	30·209	30·216	30·212	30·240	65·9	49·5	WSW
2	30·288	30·348	30·334	30·367	70·4	51·0	N	2	30·291	30·332	30·316	30·304	74·5	52·9	W
3	30·371	30·346	30·255	30·237	79·7	50·3	NW	3	30·273	30·245	30·203	30·159	67·8	56·3	W
4	30·213	30·164	30·055	29·993	76·7	58·7	W	4	30·077	30·020	29·945	29·919	60·9	54·9	SW
5	29·873	29·794	29·780	29·853	62·3	56·1	NNW	5	29·886	29·931	29·997	30·089	67·9	50·2	N
6	29·869	29·953	29·980	30·067	67·1	57·2	N	6	30·113	30·123	30·089	30·104	73·9	48·4	NW
7	30·092	30·130	30·113	30·168	73·1	55·7	N	7	30·109	30·131	30·142	30·185	67·4	53·5	WNW
8	30·184	30·181	30·118	30·102	69·4	54·9	W	8	30·158	30·103	30·019	29·976	62·8	53·2	W
9	30·080	30·079	30·014	29·991	75·4	54·6	NW	9	29·947	29·927	29·801	29·670	63·2	51·8	SW
10	29·916	29·872	29·832	29·968	71·0	52·0	SW	10	29·578	29·620	29·702	29·862	61·0	51·0	W
11	30·048	30·130	30·116	30·209	65·8	47·5	WNW	11	29·916	29·968	30·046	30·158	60·2	45·5	W
12	30·217	30·229	30·145	30·111	64·0	46·2	NW	12	30·186	30·175	30·112	30·053	55·8	43·5	W
13	30·051	29·966	29·884	29·865	62·9	51·6	NW	13	29·976	29·919	29·858	29·878	68·8	50·5	W
14	29·877	29·899	29·913	29·973	65·9	54·0	NNW	14	29·886	29·909	29·932	30·117	66·2	46·0	E
15	30·004	30·032	30·037	30·091	69·1	50·3	NE	15	30·036	30·078	30·052	30·095	66·2	52·9	NE
16	30·092	30·102	30·072	30·110	70·2	49·9	ENE	16	30·119	30·118	30·089	30·148	69·8	47·9	E
17	30·103	30·129	30·085	30·124	68·9	48·3	N	17	30·148	30·155	30·130	30·179	66·3	51·6	NNE
18	30·136	30·159	30·140	30·172	62·9	54·4	NE	18	30·193	30·221	30·200	30·226	62·4	52·8	NE
19	30·157	30·180	30·133	30·119	65·3	55·4	N	19	30·212	30·213	30·152	30·166	65·1	52·3	NE
20	30·052	29·964	29·868	29·808	64·0	56·1	ENE	20	30·129	30·086	30·119	29·952	56·1	50·8	NNE
21	29·754	29·773	29·767	29·775	71·9	58·0	SW	21	29·859	29·810	29·741	29·727	58·9	50·1	NE
22	29·751	29·766	29·820	29·914	69·0	55·4	SSE	22	29·707	29·730	29·715	29·701	60·3	49·8	W
23	29·877	29·834	29·771	29·831	56·7	53·6	S	23	29·626	29·635	29·631	29·646	61·9	46·0	NW
24	29·766	29·831	29·821	29·813	72·0	53·4	WSW	24	29·628	29·640	29·554	29·410	64·4	48·9	SW
25	29·663	29·676	29·661	29·744	68·4	56·0	SW	25	28·316	29·302	29·370	29·448	63·9	52·2	NW
26	29·765	29·805	29·764	29·677	67·9	53·9	SW	26	29·496	29·510	29·330	29·060	60·3	52·9	SW
27	29·449	29·624	29·644	29·670	67·9	55·5	SW	27	29·156	29·266	29·289	29·264	59·9	51·2	SW
28	29·553	29·475	29·438	29·541	63·3	54·0	SSW	28	29·123	29·111	29·073	29·087	60·6	51·0	SW
29	29·580	29·627	29·652	29·761	64·7	52·2	SW	29	29·107	29·207	29·416	29·573	57·4	49·3	W
30	29·802	29·871	29·849	29·944	66·3	48·9	SW	30	29·580	29·540	29·680	29·717	57·8	47·4	W
31	29·948	29·904	29·684	29·361	60·8	47·3	SSW	31	29·697	29·637	29·404	29·072	60·0	47·5	S

SEPTEMBER, 1908.

KEW.

Date.	Barometer. 4 A.M.	10 A.M.	4 P.M.	10 P.M.	Temperature. Max	Min.	Direction of wind at noon.
1	29·377	29·142	29·406	29·670	60·5	50·7	WSW
2	29·767	29·827	29·850	29·942	62·3	47·1	W
3	29·979	29·969	29·785	29·665	57·0	42·0	SE
4	29·657	29·757	29·943	30·114	54·4	47·0	N
5	30·206	30·276	30·246	30·236	59·6	41·0	SW
6	30·186	30·199	30·156	30·156	65·2	49·4	WSW
7	30·083	30·043	29·935	29·897	67·8	48·3	SSW
8	29·785	29·735	29·674	29·664	68·7	41·9	SSW
9	29·620	29·598	29·613	29·692	63·0	51·3	SW
10	29·763	29·800	29·777	29·796	58·3	45·2	W
11	29·767	29·783	29·781	29·837	58·2	44·7	N
12	29·866	29·949	30·010	30·128	58·3	42·0	N
13	30·180	30·234	30·242	30·257	59·1	37·3	W
14	30·239	30·241	30·155	30·105	63·7	48·0	SW
15	30·012	29·962	29·912	29·983	60·1	45·3	SW
16	30·102	30·177	30·140	30·101	61·1	45·7	SW
17	30·061	30·092	30·061	30·051	67·6	49·0	SSW
18	30·008	29·965	29·931	29·950	72·4	41·7	SE
19	30·002	30·076	30·055	30·052	71·0	52·0	S
20	29·968	29·920	29·918	29·996	75·3	57·2	ESE
21	29·984	30·043	30·036	30·050	64·4	48·6	W
22	30·002	29·953	29·885	29·874	59·0	42·2	SW
23	29·815	29·817	29·787	29·829	65·5	54·9	ESE
24	29·822	29·870	29·866	29·905	65·0	52·4	N
25	29·902	29·920	29·883	29·858	62·9	50·0	SW
26	29·789	29·876	29·883	29·938	63·0	52·0	SW
27	29·931	29·946	29·915	29·938	61·0	49·9	SW
28	29·926	29·995	30·016	30·112	69·0	57·1	SW
29	30·139	30·174	30·166	30·210	73·0	56·0	SSW
30	30·192	30·217	30·179	30·198	76·0	53·9	S

GLASGOW.

Date.	Barometer. 4 A.M.	10 A.M.	4 P.M.	10 P.M.	Temperature. Max	Min.	Direction of wind at noon.
1	29·037	29·186	29·424	29·577	58·8	46·7	N
2	29·636	29·648	29·733	29·863	57·4	43·1	W
3	29·895	29·903	29·861	29·888	52·3	45·4	NE
4	29·923	30·001	30·028	30·097	56·9	41·7	NNW
5	30·079	30·030	29·896	29·836	55·3	40·7	SSW
6	29·796	29·813	29·844	29·815	60·8	54·9	W
7	29·689	29·615	29·579	29·548	60·1	54·0	SW
8	29·507	29·465	29·331	29·225	58·2	53·8	S
9	29·104	29·155	29·323	29·442	54·2	46·0	NNW
10	29·464	29·579	29·659	29·752	57·4	45·7	NW
11	29·771	29·797	29·796	29·866	54·9	41·7	N
12	29·888	29·930	29·946	30·025	55·3	37·6	W
13	30·014	30·021	30·006	29·977	54·3	44·5	SW
14	29·863	29·904	29·835	29·731	56·9	53·3	SW
15	29·743	29·751	29·805	29·904	58·0	48·3	W
16	29·923	29·861	29·706	29·627	59·0	45·1	S
17	29·631	29·661	29·773	29·790	64·6	55·4	S
18	29·751	29·807	29·812	29·831	61·0	56·1	S
19	29·840	29·914	29·950	29·992	65·0	55·3	SSE
20	29·932	29·912	29·857	29·905	63·1	53·1	NE
21	29·911	29·954	29·943	29·979	60·3	55·5	NE
22	29·959	29·929	29·859	29·841	56·3	54·3	NE
23	29·827	29·836	29·837	29·901	59·3	53·0	E
24	29·917	29·953	29·937	29·927	57·2	52·9	NE
25	29·864	29·813	29·729	29·643	59·4	51·9	ESE
26	29·535	29·560	29 619	29·694	56·5	51·0	W
27	29·740	29·802	29·802	29·845	59·1	48·9	SW
28	29·780	29·766	29·748	29·788	62·4	47·9	ENE
29	29·789	29·836	29·851	29·886	64·2	59·5	S
30	29·902	29·946	29·960	30·003	67·3	59·5	S

OCTOBER, 1908.

Date.	Barometer. 4 A.M.	10 A.M.	4 P.M.	10 P.M.	Temperature. Max	Min.	Direction of wind at noon.
1	30·153	30·147	30·094	30·133	74·9	52·3	S
2	30·111	30·157	30·122	30·152	76·2	52·0	SSW
3	30·131	30·169	30·113	30·160	75·9	50·0	E
4	30·166	30·209	30·156	30·205	72·0	51·3	SSE
5	30·201	30·248	30·253	30·256	61·1	52·2	ENE
6	30·235	30·217	30·159	30·161	65·9	49·3	E
7	30·129	30·145	30·096	30·153	66·0	44·3	E
8	30·133	30·131	30·043	30·023	65·0	56·0	S
9	29·962	29·989	29·941	29·911	65·1	59·3	SW
10	29·891	29·946	29·968	30·117	64·5	50·5	SW
11	30·185	30·264	30·218	30·217	63·0	45·3	SSW
12	30·159	30·157	30·074	30·082	66·1	45·6	SE
13	30·055	30·071	30·013	30·030	62·7	51·9	ESE
14	29·989	30·013	29·985	30·032	63·9	48·0	SW
15	30·030	30·047	30·005	30·025	69·7	46·6	SE
16	29·989	29·994	29·929	29·935	63·0	53·2	ENE
17	29·909	29·964	29·970	30·022	62·9	55·0	E
18	30·018	30·038	30·003	30·015	64·3	53·6	SE
19	29·995	30·003	29·991	30·027	60·2	53·2	E
20	30·003	30 011	29·964	29·983	53·1	47·6	ESE
21	29·979	30·051	30·104	30·249	48·5	42·0	E
22	30·316	30·417	30·424	30·425	48·3	38·3	E
23	30·377	30·381	30·318	30·308	50·4	39·1	NE
24	30·218	30·139	30·121	30·127	46·2	34·9	N
25	30·136	30·172	30·156	30·106	47·9	33·6	NNE
26	29·969	29·951	29·952	29·995	51·7	45·0	E
27	29·913	29·900	29·868	29·996	49·7	36·9	SE
28	30·039	30·106	30·166	30·217	60·7	38·4	S
29	30·210	30·216	30·133	30·104	65·0	48·0	SSE
30	30·020	30·013	29·967	30·003	64·0	41·6	SE
31	30·021	30·103	30·103	30·147	61·0	47·1	SW

Date.	Barometer. 4 A.M.	10 A.M.	4 P.M.	10 P.M.	Temperature. Max	Min.	Direction of wind at noon.
1	30·001	30·019	30·014	30·064	70·8	56·5	SW
2	30·051	30·086	30·073	30·093	71·0	52·8	N
3	30·078	30·092	30·035	30·065	70·9	52·6	ESE
4	30·068	30·114	30·115	30·191	67·2	52·5	W
5	30·205	30·241	30·209	30·191	58·1	52·1	NE
6	30·139	30·111	30·054	30·036	62·4	53·3	S
7	30·000	30·012	29·999	30·016	61·1	56·8	SW
8	29·974	29·955	29·818	29·727	61·2	56·8	SSE
9	29·726	29·788	29·722	29·663	62·6	52·0	SW
10	29·604	29·640	29·703	29·814	56·1	49·6	SW
11	29·830	29·874	29·868	29·857	59·1	50·2	SW
12	29·836	29·890	29·914	29·969	60·3	55·2	SW
13	29·961	29·971	29·911	29·901	62·1	52·2	S
14	29·817	29·817	29·813	29·905	60·3	53·4	SSW
15	29·950	30·004	29·982	29·985	60·1	49·8	NE
16	29·970	29·942	29·891	29·897	61·1	51·7	E
17	29·891	29·919	29·917	29·944	57·1	52·0	E
18	29·949	29·965	29·937	29·955	57·9	51·9	ESE
19	29·943	29·949	29·917	29·897	57·3	52·3	SE
20	29·853	29·859	29·839	29·871	55·9	50·0	SE
21	29·924	30·052	30·164	30·317	53·0	42·9	E
22	30·457	30·464	30·458	30·480	49·8	37·4	E
23	30·448	30·444	30·378	30·366	48·2	32·6	SE
24	30·322	30·317	30·246	30·256	47·9	38·3	E
25	30·231	30·274	30·266	30·324	46·1	30·5	E
26	30·310	30·256	30·174	30·158	49·7	30·5	ENE
27	30·090	30·050	29·970	29·930	51·0	47·2	E
28	29·910	29·954	29·966	29·976	53·0	47·0	SW
29	29·985	30·053	30·036	30·014	57·0	46·0	NE
30	29·921	29·878	29·813	29·856	60·3	50·7	E
31	29·887	29·974	30·012	30·081	57·9	48·1	W

NOVEMBER, 1908.

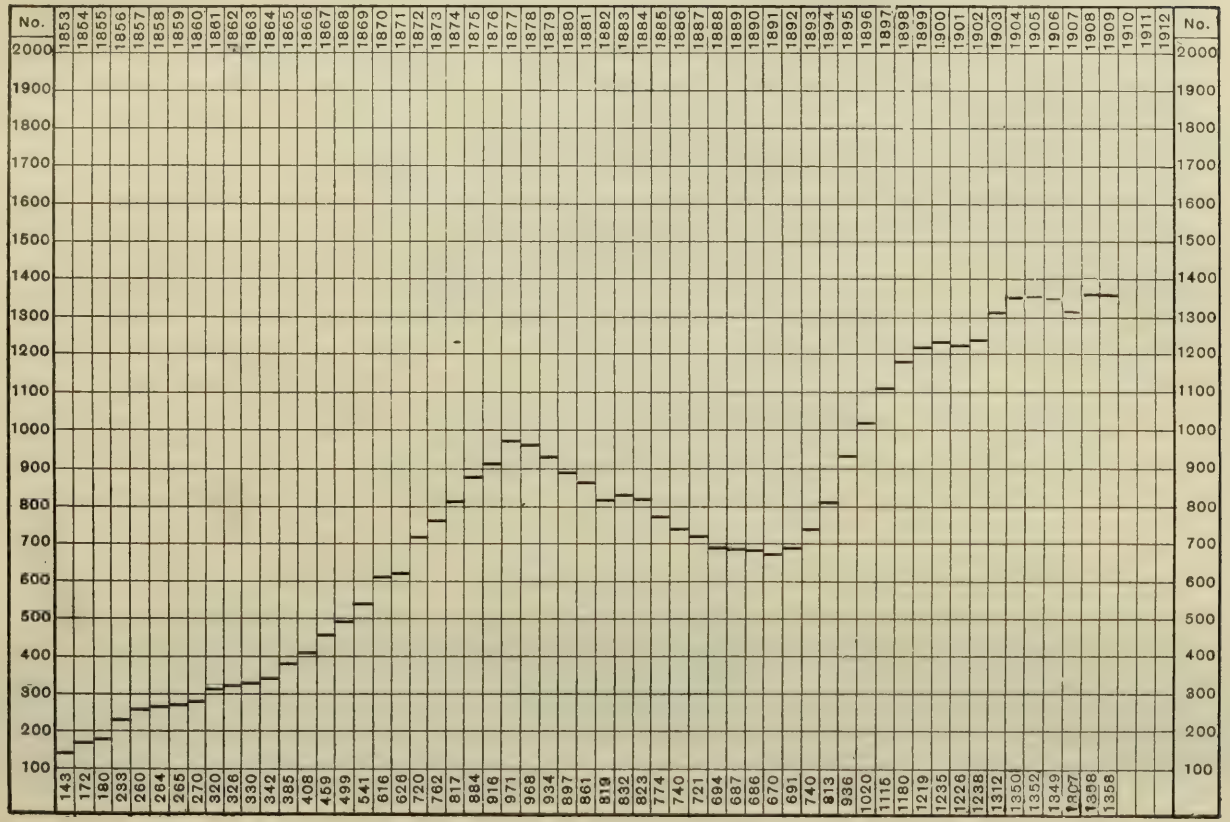
KEW.								GLASGOW.							
	BAROMETER.				TEMPERATURE.				BAROMETER.				TEMPERATURE.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.
1	30·124	30·129	30·080	30·096	58·3	47·7	E	1	30·081	30·095	30·048	30·060	48·6	37·5	N
2	30·069	30·075	30·040	30·071	56·0	47·3	E	2	30·031	30·034	30·005	30·013	50·0	45·0	E
3	30·036	30·054	29·977	29·991	53·2	41·3	E	3	29·989	29·989	29·986	30·016	51·1	48·4	E
4	29·991	30·049	30·050	30·101	53·4	43·9	NE	4	30·016	30·076	30·071	30·105	51·4	44·0	E
5	30·101	30·154	30·096	30·100	51·7	40·6	NE	5	30·103	30·117	30·067	30·073	50·9	48·0	E
6	30·076	30·098	30·068	30·078	50·9	40·2	E	6	30·066	30·090	30·076	30·062	50·2	47·2	E
7	30·014	29·961	29·812	29·760	45·2	37·9	E	7	29·998	29·959	29·853	29·825	48·4	42·2	NE
8	29·655	29·648	29·633	29·725	46·9	36·4	ENE	8	29·801	29·813	29·783	29·805	43·7	32·5	ESE
9	29·764	29·843	29·846	29·908	45·1	33·1	E	9	29·817	29·845	29·820	29·824	36·8	28·0	ESE
10	29·922	29·963	29·931	29·937	44·3	26·1	SE	10	29·804	29·782	29·690	29·656	40·3	32·0	ESE
11	29·907	29·932	29·905	29·861	55·7	37·6	SSW	11	29·645	29·658	29·538	29·445	54·8	37·8	NE
12	29·847	29·981	30·005	30·025	57·3	48·0	SW	12	29·557	29·721	29·766	29·712	55·0	47·9	SW
13	29·926	29·898	29·950	29·955	57·2	46·0	W	13	29·675	29·791	29·826	29·802	50·5	43·5	SW
14	29·862	29·885	29·870	30·017	53·6	47·9	SW	14	29·763	29·885	29·991	30·090	50·5	41·2	N
15	30·139	30·226	30·238	30·252	48·9	44·2	NNE	15	30·127	30·149	30·096	30·054	48·8	34·3	NE
16	30·222	30·204	30·128	30·122	48·6	44·9	SW	16	29·939	29·867	29·824	29·832	50·4	43·8	SW
17	30·128	30·248	30·278	30·350	51·0	41·3	W	17	29·860	29·927	30·021	30·073	49·4	42·8	W
18	30·343	30·311	30·170	30·027	51·0	37·4	WSW	18	30·010	29·898	29·787	29·751	51·3	43·7	WSW
19	29·853	29·840	30·021	30·130	49·7	37·0	NW	19	29·738	29·964	30·014	30·051	45·2	39·3	NW
20	30·126	30·107	29·971	29·934	48·9	30·4	WSW	20	29·996	29·822	29·794	29·830	46·9	34·5	NNW
21	29·935	30·009	29·959	29·724	48·5	43·1	NW	21	29·861	29·816	29·559	29·273	49·8	40·3	WSW
22	29·494	29·501	29·416	29·449	57·4	47·2	SW	22	29·187	29·190	28·998	28·957	53·4	42·7	W
23	29·454	29·819	30·015	30·170	51·2	36·1	NW	23	29·472	29·815	29·962	29·928	46·7	40·4	NNW
24	30·190	30·150	30·036	29·952	53·5	34·5	SW	24	29·747	29·598	29·406	29·536	53·8	42·0	SW
25	29·967	30·059	30·020	30·021	54·1	43·7	WSW	25	29·572	29·522	29·514	29·538	44·2	38·5	WSW
26	30·067	30·146	30·193	30·261	53·3	42·8	WSW	26	29·708	29·851	29·961	29·963	46·0	39·8	W
27	30·259	30·252	30·173	30·108	51·7	41·6	SSW	27	29·933	29·894	29·767	29·690	52·0	45·4	SW
28	30·037	30·043	30·029	30·078	53·2	42·9	S	28	29·579	29·548	29·669	29·814	54·1	46·1	W
29	30·125	30·225	30·270	30·350	54·0	48·4	S	29	29·936	30·068	30·164	30·241	47·7	42·4	SW
30	30·358	30·413	30·396	30·413	53·1	47·0	SW	30	30·254	30·303	30·294	30·324	48·0	40·3	WSW

DECEMBER, 1908.

1	30·397	30·429	30·362	30·374	47·2	40·4	SE	1	30·318	30·321	30·264	30·271	46·1	33·9	WSW
2	30·347	30·347	30·283	30·275	44·8	38·1	NNW	2	30·249	30·259	30·214	30·206	47·4	44·1	W
3	30·252	30·279	30·254	30·289	42·5	37·9	SE	3	30·184	30·185	30·151	30·150	46·9	35·5	SE
4	30·272	30·304	30·260	30·265	43·7	35·9	S	4	30·097	30·087	30·081	30·085	47·7	36·2	NE
5	30·226	30·234	30·169	30·121	48·1	43·7	SSW	5	30·013	29·902	29·740	29·747	50·3	46·4	SSW
6	30·045	30·030	29·973	29·964	49·0	40·8	WNW	6	29·786	29·846	29·880	29·940	48·2	39·5	W
7	29·987	30·117	30·167	30·165	42·8	35·5	NW	7	29·960	29·920	29·769	29·629	46·2	34·8	SW
8	30·056	29·947	29·780	29·693	49·2	32·6	SSW	8	29·423	29·408	29·421	29·427	49·2	38·8	W
9	29·684	29·697	29·687	29·671	46·4	38·4	W	9	29·397	29·371	29·260	29·223	42·1	36·9	SW
10	29·475	29·067	28·886	28·812	52·6	38·3	SW	10	29·088	28·884	28·687	28·656	41·9	38·0	E
11	28·778	28·823	28·995	29·139	44·2	38·7	NW	11	28·726	28·854	28·986	29·177	42·8	35·2	WNW
12	29·250	29·480	29·617	29·676	45·1	36·9	NW	12	29·346	29·464	29·455	29·376	40·3	35·1	WNW
13	29·553	29·508	29·468	29·565	52·3	38·1	SSW	13	29·160	29·186	29·191	29·249	43·5	34·7	SW
14	29·544	29·530	29·405	29·338	50·7	44·6	S	14	29·255	29·265	29·155	29·065	44·6	38·3	SSE
15	29·311	29·376	29·383	29·473	51·0	44·8	S	15	28·985	29·074	29·181	29·335	44·4	39·8	SW
16	29·525	29·602	29·569	29·539	49·1	39·5	SE	16	29·407	29·454	29·346	29·223	45·0	37·9	SSE
17	29·447	29·376	29·345	29·386	50·7	42·6	S	17	29·107	29·107	29·099	29·187	47·1	42·0	SW
18	29·479	29·664	29·803	29·973	46·6	34·2	SW	18	29·277	29·414	29·599	29·746	44·3	37·9	W
19	30·030	30·097	30·081	30·134	45·0	37·9	SW	19	29·840	29·896	29·896	29·916	47·6	37·1	SW
20	30·154	30·198	30·221	30·268	49·5	43·5	S	20	29·882	29·868	29·985	30·087	51·8	46·2	SW
21	30·277	30·323	30·292	30·299	51·1	45·9	S	21	30·092	30·086	30·009	29·985	51·9	41·1	S
22	30·273	30·284	30·226	30·223	45·9	39·4	S	22	29·955	29·945	29·882	29·836	52·3	48·9	SSW
23	30·190	30·208	30·160	30·129	42·1	37·0	SSE	23	29·936	30·029	29·996	29·975	51·1	39·4	E
24	30·075	30·046	29·951	29·913	38·7	36·3	E	24	29·905	29·923	29·903	29·940	48·3	33·9	SE
25	29·927	29·997	30·053	30·068	40·1	37·0	ENE	25	29·988	30·042	30·040	30·018	35·1	29·9	ESE
26	30·040	30·022	29·968	29·918	38·2	35·4	E	26	29·978	29·942	29·896	29·888	35·4	27·1	E
27	29·876	29·882	29·869	29·861	35·7	27·5	ENE	27	29·856	29·854	29·822	29·835	35·4	25·7	E
28	29·855	29·950	29·998	30·032	29·3	24·5	NE	28	29·827	29·872	29·858	29·738	30·1	24·0	SE
29	29·935	29·748	29·619	29·802	27·1	21·9	E	29	29·591	29·563	29·650	29·800	29·1	22·3	E
30	30·017	30·232	30·310	30·402	26·0	14·7	W	30	29·915	30·012	30·964	29·896	36·5	24·8	E
31	30·384	30·396	30·402	30·461	41·3	22·8	S	31	29·901	30·013	30·136	30·245	46·1	36·2	SW

Wood Memorial Hall, and Offices of The North of England Institute of Mining and Mechanical Engineers, Newcastle-upon-Tyne.

DIAGRAM EXHIBITING THE MEMBERSHIP OF THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS SINCE ITS FOUNDATION IN 1852.



THE NORTH OF ENGLAND INSTITUTE

OF

Mining and Mechanical Engineers.

ANNUAL REPORT OF THE COUNCIL

AND

ACCOUNTS FOR THE YEAR 1908-1909;

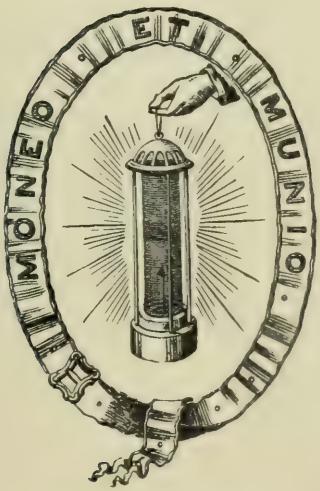
LIST OF

COUNCIL, OFFICERS AND MEMBERS

FOR THE YEAR 1909-1910;

ETC.

1908-1909.



NEWCASTLE-UPON-TYNE: PUBLISHED BY THE INSTITUTE.

PRINTED BY ANDREW REID & COMPANY, LIMITED, LONDON AND NEWCASTLE-UPON-TYNE

1909.

CONTENTS.

	PAGE.
Annual Report of the Council, 1908-1909	v
Annual Report of the Finance Committee	x
General Statement, June 30th, 1909	xi
The Treasurer in Account with The North of England Institute of Mining and Mechanical Engineers for the Year ending June 30th, 1909	xii
The Treasurer of The North of England Institute of Mining and Mechanical Engineers in Account with Subscriptions, 1908-1909	xiv
List of Committees appointed by the Council, 1909-1910	xvi
Officers, 1909-1910	xvii
Patrons	xviii
Honorary Members	xviii
Members	xix
Associate Members	xlvi
Associates	l
Students	lvi
Subscribers	lviii

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

ANNUAL REPORT OF THE COUNCIL, 1908-1909.

The Council regret to have to refer to the great loss that the Institute has sustained through the death of Mr. Henry Lawrence, who had been a Member for over forty years, and who had served on the Council, with hardly a break, since the year 1882. They also have to deplore the death of Mr. Bennett Hooper Brough, who had been associated with the Institute since the year 1887, and who had for a number of years acted as one of its representatives on the Council of The Institution of Mining Engineers.

The following table shows the progress of the membership during recent years:—

Year ending August 1st.	1906.	1907.	1908.	1909.
Honorary members	25	21	21	22
Members	931	903	942	935
Associate members	114	108	105	103
Associates	190	194	209	210
Students	56	47	48	54
Subscribers	33	34	33	34
Totals	1,349	1,307	1,358	1,358

The members are to be congratulated that the membership roll has been maintained at its present high figure.

The deaths (10) include the following: Members: Thomas Axtell, John Batey, Bennett Hooper Brough, William Hedley, Henry Lawrence, William Peile, John Alexander George Ross and John Watson Spencer. Associate members: Augustus Edward Burdon and Scott Gunn.

The resignations (45) include the following:—Members: R. Hugh M. Buddle Atkinson, Henry Barton, Joseph James Burton, Thomas Philip Edward Butt, Percy Sidney James Cooper, Joseph Dobbs, John Robinson Felton, William Frecheville, George Brabbon Harrison, Albert James Hill, John House, Henrich Wilhelm Ferdinand Kayser, Percy Ewbank Lee, John Alexander McDonald, Francis James Oakes, Jun., Davidge Page, William Piercy, Henry Willock Ravenshaw, Arthur H. Reid, Francis Reid, William Rich, Friedrich Senstius, Thomas Shewan, Alfred Simeon Tallis, Charles Lacy Thompson, Joseph Burr Tyrrell, Gardner Frederick Williams, Robert Winstanley, Charles Frederick Wormald and James Young. Associate members: William Eastwood, Thomas Lambert, Wilson Ormrod and Henry Pickering. Associates: John Clough, Robert Crombie, Edward Elves, John Galloway, George Stoker Gordon, Thomas Morland, Christopher Robinson, George Tweddell and Christopher Wilson. Student: Feliciano Xable.

The following gentlemen (28) have ceased to be members during the past year:—Members: Gaspard Robert de Mussenden Carey, Robert Dixon, Eugene Fieuzet, John Thomas Foulis, Thomas Lewis Fryar, George Alfred Greener, James Hooper, Charles Edward Hope, Edward Hopkins, David Howells, Frederick Ernest Jacob, Henry Howard Johnson, Paul J. Mallmann, James Miller, Peter Scholer, Elgin Scott, Frederick Bowes Scott, Harry Sladden, John Thomas Wilkinson, Henry J. Carnegie Williams, John Richard Williams and Frederick Augustus Yerbury. Associate members: John Eccles Aspinall and John Rosen. Associates: Edward Aston Allport, George Emmerson, Cecil Graham and John Joseph Marshall.

The Library has been maintained in an efficient condition during the year; the additions, by donation, exchange and purchase, include 287 bound volumes and 16 pamphlets, reports, etc.; and the Library now contains about 11,837 volumes and 396 unbound pamphlets. A card-catalogue of the books, etc., contained in the Library renders them easily available for reference.

Members would render useful service to the profession by the presentation of books, reports, plans, etc., to the Institute, to be preserved in the Library, and thereby become available for reference.

The Most Honourable the Marquess of Londonderry has presented to the Institute some old wooden pumps found in the workings of Rainton colliery, which, after being exhibited for some time in the Wood Memorial Hall, have been loaned to Armstrong College.

An exchange of *Transactions* has been arranged, during the year, with The North-west Mining News.

The courses of lectures for colliery engineers, enginewrights, and apprentice mechanics have been continued at Armstrong College, Newcastle-upon-Tyne. The lectures are delivered on Saturday afternoons, and the three years' course embraces the following subjects:—

1909-1910. Michaelmas Term, (1) Machine Drawing, and (2) the Chemistry of Fuel. Epiphany Term, (3) Strength of Materials (with experimental illustrations), and (4) Experimental Mechanics.

1910-1911. Michaelmas Term, (5) The Steam-engine, and (6) Theoretical Electricity. Epiphany Term, (7) Electrical Engineering, and (8) Haulage and Winding.

1911-1912. Michaelmas Term, (9) Transmission of Power, and (10) Pumping and Ventilation. Epiphany Term, (11) Metallurgy of Iron and Steel, and (12) Mining Machinery (mainly machinery used underground).

Several colliery-owners have paid the fees (£1 10s. per annum) and railway expenses of pupils attending the classes from their collieries. During the past year, the lectures of the Michaelmas Term on the Transmission of Power and on Pumping and Ventilation were attended by 30 students, 24 of whom sat for examination and 17 passed; and during the Epiphany Term, the lectures on the Metallurgy of Iron and Steel and on Mining Machinery were attended by 31 students, 22 of whom sat for examination and 16 passed. Certificates have been awarded to

the following students, who have completed the three years' course: Messrs. J. A. Lee, G. Malone and J. G. Reavely. The first and second prizes for the Session 1908-1909, have been awarded to Messrs. P. Bateson and J. A. Lee, respectively.

Supplementary volumes to *An Account of the Strata of Northumberland and Durham, as proved by Borings and Sinkings*, are in course of publication, a large number of sections having been received from members and other friends.

Mr. Thomas Douglas continues to represent the Institute as a Governor of Armstrong College, and Mr. John H. Merivale, in conjunction with the President (Mr. T. E. Forster), represents the Institute on the Council of the College.

Mr. George May continues to represent the Institute upon the Board of Directors of the Institute and Coal Trade Chambers Company, Limited.

The Rev. G. M. Capell will represent the Institute at the Conference of the Delegates of the Corresponding Societies of the British Association for the Advancement of Science, to be held in London on October 25th and 26th, 1909.

The constitution of the University of Durham College of Medicine has recently been amended, and under the new Articles of Association the President of the Institute will be a Representative Governor upon the Court of Governors during his term of office.

The representatives of the Institute upon the Council of The Institution of Mining Engineers during the past year were as follows:— Messrs. R. S. Anderson, William Armstrong, R. C. Aubrey, W. C. Blackett, the late Bennett H. Brough, A. G. Charleton, Frank Coulson, Benjamin Dodd, T. E. Forster, J. W. Fryar, William Galloway, T. Y. Greener, Reginald Guthrie, Samuel Hare, A. M. Hedley, J. P. Kirkup, Philip Kirkup, C. C. Leach, Henry Louis, George May, John H. Merivale, J. J. Prest, John Simpson, C. H. Steavenson, J. G. Weeks and R. L. Weeks.

Under the will of the late Mr. John Daglish, funds have been placed at the disposal of Armstrong College for founding a Travelling Fellowship, to be called the "Daglish" Fellowship, candidates for which must be nominated by the Institute. Mr. Henry Moore Hudspeth was in January, 1909, awarded the Fellowship, and suitable arrangements for his gaining knowledge and experience abroad have been made.

G. C. Greenwell gold, silver and bronze medals may be awarded annually for approved papers "recording the results of experience of interest in mining, and especially where deductions and practical suggestions are made by the writer for the avoidance of accidents in mines."

Prizes for books have been awarded to the writers of the following papers, communicated to the members during the year 1907-1908:—

"The Occurrence and Commercial Uses of Fluorspar." By Mr. William Morley Egglestone.

"The Strength of Cast-iron Tubbing for Deep Shafts." By Dr. John Morrow.

The papers printed in the *Transactions* during the year are as follows:—

"The Working of the Inclined Seams in the St. Étienne Coal-field, at the Montrambert and La Béraudière Collieries." By Mr. Hugh Clarkson Annett, Assoc. I.M.E.

"Hydraulic Stowing of Gob at Shamrock I. and II. Colliery, Herne, Westphalia, Germany." By Mr. Hugh Clarkson Annett, Assoc. I.M.E.

"Repairing Leaky Seams." By Mr. Ugo Bagnoli, M.I.M.E.

"Notes on a Small Contrivance to More Easily Detect Fire-damp." By Mr. W. C. Blackett, M.I.M.E.

"Report of Delegate to the Jubilee Meeting of the Société de l'Industrie Minérale, 1908." By Mr. A. M. Hedley, M.I.M.E.

"A Short Description of the Various Types of Coal Cargo-steamers and of Doxford's New Self-discharging Steamer." By Mr. John Kirsopp, Jun., M.I.M.E.

"Memoir of Henry Lawrence." By Mr. John H. Merivale, M.I.M.E.

"Note on the Effect of an Igneous Dyke on a Natal Coal-seam." By Mr. G. H. Stanley, M.I.M.E.

"Note on a Deposit of Sulphur in a Colliery Water." By Mr. G. H. Stanley, M.I.M.E.

"The 'Bold' Box-controller and Box-switch." By Mr. J. G. Thompson.

"Coal-mining on the Kirghese Steppe, in the Akmolinsk District of South-western Siberia." By Mr. Edward Watson, M.I.M.E.

In connection with the Annual General Meeting held upon August 1st, 1908, a visit was paid to the Hancock Museum of the Natural History Society of Northumberland, Durham and Newcastle-upon-Tyne, and the Loan Exhibition of Forestry. The exhibits were described by Mr. John F. Annand, Lecturer in Forestry at Armstrong College.

Another maintenance-grant of £50 towards the cost of conducting further experiments on the Inflammability of Mixtures of Coal-dust and Air, together with £10 for additional apparatus, has been made to Dr. P. Phillips Bedson.

A Committee has been appointed, with Mr. Stanley Smith as Secretary, to report upon the Carboniferous Limestone Formation of the North of England, with Special Reference to its Coal Resources.

The collection of safety-lamps was loaned to the Franco-British Exhibition, and the Council have pleasure in announcing that they have been granted a Diploma for the same.

A number of Silesian mining engineers visited Newcastle-upon-Tyne on July 22nd and 23rd, 1909, and visits to collieries, works, etc., were arranged for their entertainment. The thanks of the Institute have been sent to the owners of the collieries, works, etc., visited.

During the past year the old office and the stock-room of the Institute have been decorated and furnished as two reading, writing and smoke rooms, with an entrance by spiral staircase from the Library, and it is hoped that they will prove a convenience, and also add to the comfort of the members using the rooms of the Institute.

The rooms of the Institute have been used, during the year, by the Newcastle-upon-Tyne Association of Students of the Institution of Civil Engineers; the North of England Gas Managers' Association; the Newcastle District Telephone

Society ; the Newcastle-upon-Tyne Economic Society ; the Newcastle-upon-Tyne and Gateshead Gas Company ; the Northumberland and Durham Provincial Committee of the Surveyors' Institution ; and the Institute of Mining Electrical Engineers.

The Council in reporting that the North-eastern Railway Company had granted reduced railway-fares to members attending general or excursion meetings of the Institute, expressed the hope that the concession would lead to an increased attendance at the meetings. They regret that no material increase has resulted, but trust that in the future a larger number of members will avail themselves of the privilege.

The Institution of Mining Engineers is now in the twenty-first year of its existence, and the members are to be congratulated upon its continued success, and the ever increasing membership of the associated Institutes. During the course of the year it was considered that the best interests of the Institution would be served by placing the guidance of its affairs in the hands of an Honorary and an Assistant Secretary, Prof. L. T. O'Shea kindly undertaking the former, while Mr. Percy Strzelecki was appointed to the latter position. The headquarters of the Institution have been removed to London, chambers having been taken in Albany Buildings, 39, Victoria Street, Westminster, S.W., where a reading and writing room have been furnished for the convenience of members. Meetings were held in Edinburgh in September, 1908, and in London in June, 1909, the attendance in each case being of a satisfactory nature.

The Twentieth Annual General Meeting of The Institution of Mining Engineers will be held in Newcastle-upon-Tyne upon September 15th, 16th and 17th, 1909, and a Committee has been appointed to make the necessary arrangements.

ANNUAL REPORT OF THE FINANCE COMMITTEE.

The Finance Committe submit herewith a statement of accounts for the twelve months ending June 30th, 1909, duly audited.

The total receipts were £2,920 7s. 2d. Of this amount, £32 6s. represents subscriptions paid in advance, leaving £2,888 1s. 2d. as the ordinary income of the year, compared with £2,805 8s. in the previous year. The amount received for ordinary current-year subscriptions was £2,287 7s., and arrears £222 8s., as against £2,218 10s. and £239 18s. respectively in the year 1907-1908. *Transactions* sold realised £21 14s. 1d., as compared with £11 5s. 8d. in the earlier period; the sum received for interest on investments was £356 12s. 1d., the amount in the former year being £335 14s. 4d.

The expenditure was £2,994 18s. 3d., that for the previous year being £2,627 2s. 3d. The principal items making up the increase comprise the furnishing of the new offices and smoke-rooms, the contribution towards the maintenance of the offices of The Institution of Mining Engineers in London, grant for further experiments on the inflammability of mixtures of coal-dust and air, expenses of the Committee to Report upon the Carboniferous Limestone Formation of the North of England, with Special Reference to its Coal Resources, travelling expenses, and law charges; the latter being for services extending over a period of 13 years.

It will be seen from the above figures that the expenditure exceeded the income by £74 11s. 1d., and deducting this amount from the balance of £504 15s. 3d., brought forward from the previous year, leaves the sum of £430 4s. 2d. to carry forward.

The names of 33 persons have been struck off the membership list in consequence of non-payment of subscriptions. The amount of subscriptions written off was £151 10s., of which £78 18s. was for sums due for the year 1908-1909, and £72 12s. for arrears. It is probable that a considerable proportion of these amounts will be recovered and credited in future years. Of the amounts previously written off, £29 8s. was recovered during the past year.

JOHN H. MERIVALE, *Past-President.*

August 7th, 1909.

LIABILITIES.

	£ s. d.	£ s. d.
Subscriptions paid in advance during the current year		34 8 0
The George Clementson Greenwell prize fund	100 0 0	
Less, paid for medals	70 1 4	
		29 18 8
Capital		12,593 2 7
		£12,657 9 3

We have examined the above balance-sheet with the books, vouchers and securities relating thereto, and certify that, in our opinion, it is correct. We have accepted the assets, books, pictures, maps, etc., and *Transactions* and other publications, as valued by your officials.

JOHN G. BENSON AND SONS,
CHARTERED ACCOUNTANTS.

Newcastle-upon-Tyne,
July 31st, 1909.

ASSETS.

	£ s. d.	£ s. d.	£ s. d.
Balance of account at bankers:			
Deposit account	125 0 0		
Current „	222 12 3		
		347 12 3	
„ in Treasurer's hands		80 19 9	
Outstanding accounts due from authors for excerpts		1 12 2	
			430 4 2
Arrears of subscriptions			273 4 0
179 shares in the Institute and Coal-trade Chambers Company, Limited (at cost) ...		4,100 0 0	
Institute and Coal-trade Chambers Company, Limited (mortgage)		1,400 0 0	
£340 consolidated 5 per cent. preference stock of the Newcastle and Gateshead Water Company (at cost)		499 17 6	
£450 ordinary stock of the Newcastle and Gateshead Gas Company (at cost)		487 13 6	
			6,487 11 0
(Of the above amount, £1,659 is due to life-subscriptions account.)			
Value of *Transactions* and other publications, as per stock account		316 10 1	
Books, pictures, maps, furniture and fittings		5,150 0 0	
			5,466 10 1
			£12,657 9 3

DR. THE TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND FOR THE YEAR ENDING

	£ s. d.	£ s. d.
June 30th, 1908.		
To balance of account at bankers	424 16 4	
„ „ in Treasurer's hands	77 12 3	
„ outstanding accounts due from authors for excerpts	2 6 8	
		504 15 3
June 30th, 1909.		
To dividend of 7½ per cent. on 179 shares of £20 each in the Institute and Coal-trade Chambers Company, Limited, for the year ending June 30th, 1909 ...	268 10 0	
„ interest on mortgage of £1,400 with the Institute and Coal-trade Chambers Company, Limited	49 0 0	
„ dividend on £340 consolidated 5 per cent. preference stock of the Newcastle and Gateshead Water Company	16 3 0	
„ dividend on £450 ordinary stock of the Newcastle and Gateshead Gas Company	19 10 0	
„ interest on deposit account	3 9 1	
		356 12 1
To sales of *Transactions*		21 14 1
To SUBSCRIPTIONS FOR 1908-1909 AS FOLLOWS:—		
760 members ... ... @ £2 2s.	1,596 0 0	
83 associate members ... ... @ £2 2s.	174 6 0	
187 associates ... ... @ £1 5s.	233 15 0	
41 students ... ... @ £1 5s.	51 5 0	
50 new members ... ... @ £2 2s.	105 0 0	
8 new associate members ... ... @ £2 2s.	16 16 0	
10 new associates ... ... @ £1 5s.	12 10 0	
15 new students ... ... @ £1 5s.	18 15 0	
	2,208 7 0	
32 subscribing firms	115 10 0	
1 new subscribing firm	2 2 0	
	2,325 19 0	
Less, subscriptions for current year paid in advance at end of last year	38 12 0	
	2,287 7 0	
Add, arrears received	222 8 0	
	2,509 15 0	
Add, subscriptions paid in advance during current year	32 6 0	
		2,542 1 0
		£3,425 2 5

INSTITUTE OF MINING AND MECHANICAL ENGINEERS — CR.
JUNE 30TH, 1909.

June 30th, 1909.	£	s.	d.	£	s.	d.
By salaries and wages	498	8	6			
„ insurance	13	5	9			
„ rent, rates and taxes	34	9	3			
„ heating, lighting, etc.	51	18	9			
„ furniture and repairs	234	13	4			
„ bankers' charges	21	0	0			
„ Wood Memorial Hall	34	7	2			
„ library	21	2	1			
„ printing, stationery, etc.	114	9	5			
„ postages, etc.	63	16	11			
„ incidental expenses...	69	3	2			
„ travelling expenses	46	2	8			
„ prizes for papers	13	13	0			
„ *Subject-matter Index of Mining, Mechanical, and Metallurgical Literature*	2	16	0			
„ law charges	96	7	2			
„ reporting of general meetings	10	10	0			
„ library catalogue	75	0	0			
„ grant for further experiments on the inflammability of mixtures of coal-dust and air	60	0	0			
„ Committee to report upon the Carboniferous Limestone Formation of the North of England, with Special Reference to its Coal Resources...	20	8	9			
				1,481	11	11
By The Institution of Mining Engineers	£1,306	0	6			
„ „ „ : Guarantee Fund	210	3	10			
	1,516	4	4			
Less, amounts paid by authors for excerpts	2	18	0			
				1,513	6	4
				2,994	18	3
By balance of account at bankers:						
Deposit account 125 0 0						
Current „ 222 12 3						
	347	12	3			
„ „ in Treasurer's hands	80	19	9			
„ outstanding accounts due from authors for excerpts	1	12	2			
				430	4	2
				£3,425	2	5

DR. THE TREASURER OF THE NORTH OF ENGLAND INSTITUTE OF MINING

		£ s. d.	£ s. d.	£ s. d.
To 942 members,				
52 of whom have paid life-compositions.				
890	@ £2 2s.		1,869 0 0	
To 105 associate members,				
9 of whom have paid life-compositions				
96	@ £2 2s.		201 12 0	
To 209 associates,				
1 of whom has paid a life-composition.				
208	@ £1 5s.		260 0 0	
To 48 students	@ £1 5s.		60 0 0	
To 33 subscribing firms			117 12 0	
				2,508 4 0
To 50 new members	@ £2 2s.		105 0 0	
To 8 new associate members	@ £2 2s.		16 16 0	
To 10 new associates	@ £1 5s.		12 10 0	
To 15 new students	@ £1 5s.		18 15 0	
To 1 new subscribing firm			2 2 0	
				155 3 0
To arrears, as per balance sheet, 1907-1908			280 6 0	
Add, arrears considered irrecoverable, but since paid ...			29 8 0	
				309 14 0
				2,973 1 0
To subscriptions paid in advance				32 6 0
				£3,005 7 0

AND MECHANICAL ENGINEERS IN ACCOUNT WITH SUBSCRIPTIONS, 1908-1909. CR.

			PAID.	UNPAID.	STRUCK OFF LIST.
			£ s. d.	£ s. d.	£ s. d.
By 760	members, paid	@ £2 2s.	1,596 0 0	.....	.....
99	„ unpaid ...	@ £2 2s.	.....	207 18 0	.....
2	„ excused payment	@ £2 2s.	.....	.....	4 4 0
4	„ dead	@ £2 2s.	.....	.....	8 8 0
25	„ struck off list	@ £2 2s.	.....	.....	52 10 0
890					
By 83	associate members, paid	@ £2 2s.	174 6 0	.....	.....
10	„ „ unpaid	@ £2 2s.	.....	21 0 0	.....
1	„ „ dead	@ £2 2s.	.....	.....	2 2 0
2	„ „ struck off list	@ £2 2s.	.....	.....	4 4 0
96					
By 187	associates, paid	@ £1 5s.	233 15 0	.....	.....
16	„ unpaid ...	@ £1 5s.	.....	20 0 0	.....
5	„ struck off list	@ £1 5s.	.....	.....	6 5 0
208					
By 41	students, paid	@ £1 5s.	51 5 0	.....	.....
6	„ unpaid ...	@ £1 5s.	.....	7 10 0	.....
1	„ struck off list...	@ £1 5s.	.....	.....	1 5 0
48					
By 32	subscribing firms, paid		115 10 0	.....	.....
1	„ „ unpaid		.....	2 2 0	.....
33					
By 50	new members, paid ...	@ £2 2s.	105 0 0	.....	.....
By 8	new associate members, paid	@ £2 2s.	16 16 0	.....	.....
By 10	new associates, paid ...	@ £1 5s.	12 10 0	.....	.....
By 15	new students, paid ...	@ £1 5s.	18 15 0	.....	.....
By 1	new subscribing firm, paid		2 2 0	.....	.....
			2,325 19 0	258 10 0	78 18 0
By arrears	... ...		222 8 0	14 14 0	72 12 0
			2,548 7 0		
By subscriptions paid in advance	... ...		32 6 0	.....	.....
			2,580 13 0	273 4 0	151 10 0
					273 4 0
					2,580 13 0
					£3,005 7 0

LIST OF COMMITTEES APPOINTED BY THE COUNCIL, 1909-1910.

Finance Committee.

Mr. Frank Coulson.
Mr. T. Douglas.
Mr. T. Y. Greener.
Mr. T. E. Jobling.
Mr. George May.
Mr. John Simpson.
Mr. J. B. Simpson.
Mr. J. G. Weeks.

Arrears Committee.

Mr. Frank Coulson.
Mr. T. Douglas.
Mr. T. Y. Greener.
Mr. T. E. Jobling.
Mr. George May.
Mr. John Simpson.
Mr. J. B. Simpson.
Mr. J. G. Weeks.

Library Committee.

Mr. R. S. Anderson.
Mr. Sidney Bates.
Mr. J. P. Kirkup.
Mr. George May.
Mr. H. Palmer.
Mr. F. R. Simpson.
Mr. John Simpson.
Mr. J. G. Weeks.

Prizes Committee.

Mr. Samuel Hare.
Mr. C. C. Leach.
Prof. H. Louis.
Mr. A. D. Nicholson.
Mr. H. Palmer.
Mr. John Simpson.

Borings and Sinkings Committee.

Mr. J. B. Atkinson.
Mr. R. Donald Bain.
Mr. W. C. Blackett.
Mr. Frank Coulson.
Mr. T. E. Forster.
Prof. G. A. L. Lebour.
Prof. H. Louis.
Mr. A. D. Nicholson.
Mr. R. F. Spence.

Committee to Report upon the Carboniferous Limestone Formation of the North of England, with Special Reference to its Coal Resources.

Mr. J. B. Atkinson.
Prof. G. A. L. Lebour.
Mr. A. D. Nicholson.
Mr. F. R. Simpson.

Reference Committee for Papers to Read.

(a) Coal-mining.

Mr. R. W. Berkley.
Mr. W. C. Blackett.
Mr. C. S. Carnes.
Mr. Benjamin Dodd.
Mr. Mark Ford.
Mr. A. M. Hedley.
Mr. C. C. Leach.
Prof. H. Louis.
Mr. George May.
Mr. J. H. Merivale.
Mr. H. Palmer.
Mr. John Simpson.
Mr. A. L. Steavenson.
Mr. Simon Tate.

(b) Metalliferous Mining.

Mr. R. Donald Bain.
Mr. A. M. Hedley.
Prof. H. Louis.
Mr. J. H. Merivale.
Mr. A. D. Nicholson.
Mr. A. L. Steavenson.
Mr. C. H. Steavenson.

(c) Geological.

Mr. R. S. Anderson.
Mr. R. Donald Bain.
Mr. Samuel Hare.
Mr. T. E. Jobling.
Prof. G. A. L. Lebour.
Mr. J. H. Merivale.
Mr. John Simpson.

(d) Mechanical and Electrical Engineering.

Mr. Sidney Bates.
Mr. W. C. Blackett.
Mr. C. S. Carnes.
Mr. Austin Kirkup.
Mr. J. P. Kirkup.
Mr. C. C. Leach.
Mr. J. H. Merivale.
Mr. John Morison.
Mr. W. C. Mountain.
Mr. J. H. Nicholson.
Hon. C. A. Parsons.
Mr. A. L. Steavenson.

(e) Civil Engineering.

Mr. Benjamin Dodd.
Mr. J. H. B. Forster.
Mr. T. E. Forster.
Mr. W. C. Mountain.
Mr. M. W. Parrington.
Mr. F. R. Simpson.
Mr. J. B. Simpson.
Mr. A. L. Steavenson.

(f) Chemical.

Prof. P. Phillips Bedson.
Mr. R. W. Berkley.
Mr. Benjamin Dodd.
Dr. G. P. Lishman.

N.B.—The President is *ex-officio* on all Committees.

OFFICERS, 1909-1910.

PAST-PRESIDENTS (*ex-officio*).

Sir LINDSAY WOOD, Bart., The Hermitage, Chester-le-Street.
Mr. JOHN BELL SIMPSON, Bradley Hall, Wylam, S.O., Northumberland.
Mr. ADDISON LANGHORNE STEAVENSON, Durham.
Mr. THOMAS DOUGLAS, The Garth, Darlington.
Mr. GEORGE MAY, Clervaux Castle, Croft, Darlington.
Mr. WILLIAM ARMSTRONG, Elmfield Lodge, Gosforth, Newcastle-upon-Tyne.
Mr. JOHN GEORGE WEEKS, Bedlington, S.O., Northumberland.
Mr. WILLIAM OUTTERSON WOOD, South Hetton, S.O., County Durham.
Mr. THOMAS WALTER BENSON, Collingwood Buildings, Collingwood Street, Newcastle-upon-Tyne.
Mr. JOHN HERMAN MERIVALE, Togston Hall, Acklington, S.O., Northumberland.

PRESIDENT.

Mr. THOMAS EMERSON FORSTER, 3, Eldon Square, Newcastle-upon-Tyne.

VICE-PRESIDENTS.

Mr. JOHN BOLAND ATKINSON, H.M. Inspector of Mines, 2, Devonshire Terrace, Newcastle-upon-Tyne.
Mr. WILLIAM CUTHBERT BLACKETT, Acorn Close, Sacriston, Durham.
Mr. THOMAS YOUNG GREENER, West Lodge, Crook, S.O., County Durham.
Mr. HENRY PALMER, Medomsley, S.O., County Durham.
Mr. MATTHEW WILLIAM PARRINGTON, Wearmouth Colliery, Sunderland.
Mr. JOHN SIMPSON, Heworth Colliery, Felling, S.O., County Durham.

RETIRING VICE-PRESIDENT (*ex-officio*).

Mr. RICHARD DONALD BAIN, H.M. Inspector of Mines, Durham.

COUNCILLORS.

Mr. ROBERT SIMPSON ANDERSON, Benwell View, Bentinck Road, Newcastle-upon-Tyne.
Mr. SIDNEY BATES, The Grange, Prudhoe, Ovingham, S.O., Northumberland.
Mr. CHARLES SPEARMAN CARNES, Marsden Hall, South Shields.
Mr. FRANK COULSON, Shamrock House, Durham.
Mr. BENJAMIN DODD, Bearpark Colliery, Durham.
Mr. MARK FORD, Washington Colliery, Washington Station, S.O., County Durham.
Mr. SAMUEL HARE, Howlish Hall, Bishop Auckland.
Mr. ARTHUR MORTON HEDLEY, Blaydon Burn, Blaydon-upon-Tyne, S.O., County Durham.
Mr. THOMAS EDGAR JOBLING, Bebside, S.O., Northumberland.
Mr. JOHN PHILIP KIRKUP, Burnhope, Durham.
Mr. CHARLES CATTERALL LEACH, Seghill Colliery, Seghill, Dudley, S.O., Northumberland.
Mr. HENRY LOUIS, 4, Osborne Terrace, Newcastle-upon-Tyne.
Mr. WILLIAM CHARLES MOUNTAIN, The Hermitage, Gateshead-upon-Tyne.
Mr. ARTHUR DARLING NICHOLSON, H.M. Inspector of Mines, 2, Grainger-ville, Newcastle-upon-Tyne.
Mr. JOHN HODGSON NICHOLSON, Cowpen Colliery Office, Blyth.
Mr. FRANK ROBERT SIMPSON, Hedgefield House, Blaydon-upon-Tyne, S.O., County Durham.
Mr. SIMON TATE, Trimdon Grange Colliery, County Durham.
Mr. RICHARD LLEWELLYN WEEKS, Willington, S.O., County Durham.

TREASURER.

Mr. REGINALD GUTHRIE, Neville Hall, Newcastle-upon-Tyne.

HONORARY SECRETARY.

Mr. JOHN HERMAN MERIVALE, Neville Hall, Newcastle-upon-Tyne.

SECRETARY.

Mr. LAWRENCE AUSTIN, Neville Hall, Newcastle-upon-Tyne.

AUDITORS.

Messrs. JOHN G. BENSON and SONS, Newcastle-upon-Tyne.

BANKERS.

LLOYDS BANK LIMITED (LAMBTON'S BRANCH), Grey Street, Newcastle-upon-Tyne.

LIST OF MEMBERS,

AUGUST 7, 1909.

PATRONS.

His Grace the DUKE OF NORTHUMBERLAND.
The Most Honourable the MARQUESS OF LONDONDERRY.
The Right Honourable the EARL OF DURHAM.
The Right Honourable the EARL GREY.
The Right Honourable the EARL OF LONSDALE.
The Right Honourable the EARL OF WHARNCLIFFE.
The Right Reverend the LORD BISHOP OF DURHAM.
The Right Honourable LORD ALLENDALE.
The Right Honourable LORD BARNARD.
The Right Honourable LORD RAVENSWORTH.
The Very Reverend the DEAN AND CHAPTER OF DURHAM.

HONORARY MEMBERS (Hon. M.I.M.E.).

* Honorary Members during term of office only.

	Date of Election.
1*JOHN BOLAND ATKINSON, H.M. Inspector of Mines, 2, Devonshire Terrace, Newcastle-upon-Tyne	Aug. 4, 1888
2*WILLIAM NICHOLAS ATKINSON, H.M. Inspector of Mines, Bridgend	Aug. 4, 1888
3*RICHARD DONALD BAIN, H.M. Inspector of Mines, Durham	Dec. 12, 1896
4*Prof. PETER PHILLIPS BEDSON, Armstrong College, Newcastle-upon-Tyne	Feb. 10, 1883
5 THOMAS BELL, 40, Esplanade Road, Scarborough	Dec. 12, 1896
6 JOSEPH DICKINSON, 3, South Bank, Sandy Lane, Pendleton, Manchester	Dec. 13, 1852
7 Prof. WILLIAM GARNETT, London County Council Education Office, Victoria Embankment, London, W.C.	Nov. 24, 1894
8*JOHN GERRARD, H.M. Inspector of Mines, Worsley, Manchester	June 11, 1892
9*FREDERICK AUGUSTUS GRAY, H.M. Inspector of Mines, 7, Victoria Square, Penarth	June 14, 1902
10*HENRY HALL, I.S.O., H.M. Inspector of Mines, Rainhill, S.O., Lancashire	March 4, 1876
11*HUGH JOHNSTONE, H.M. Inspector of Mines, Stafford ...	Oct. 13, 1906
12*Prof. GEORGE ALEXANDER LOUIS LEBOUR, Armstrong College, Newcastle-upon-Tyne. *Transactions*, etc., sent to Radcliffe House, Corbridge, S.O., Northumberland	Nov. 1, 1879
13*Prof. HENRY LOUIS, Armstrong College, Newcastle-upon-Tyne. *Transactions* sent to The Librarian, Armstrong College, Newcastle-upon-Tyne	Dec. 12, 1896
14*ROBERT McLAREN, H.M. Inspector of Mines, Craigmore, 77, Colinton Road, Edinburgh	Dec. 13, 1902
15*JOSEPH SAMUEL MARTIN, I.S.O., H.M. Inspector of Mines, The Vikings, 16, Durdham Park, Bristol	Aug. 4, 1888
16 DANIEL MURGUE, 1, rue St. Honoré, St. Étienne, Loire, France	June 20, 1908
17*JOHN MARTINE RONALDSON, H.M. Inspector of Mines, 44, Athole Gardens, Glasgow	Aug. 4, 1888
18*ARTHUR HENRY STOKES, H.M. Inspector of Mines, Greenhill, Derby	Aug. 4, 1888
19*Prof. HENRY STROUD, Armstrong College, Newcastle-upon-Tyne	Nov. 5, 1892

Date of Election.

20*JETHRO JUSTIMAN HARRIS TEALL, Director of the Geological Survey of the United Kingdom, 28, Jermyn Street, London, S.W. ... ... Aug. 3, 1901

21*WILLIAM WALKER, H.M. Inspector of Mines, 212, Osmaston Road, Derby ... ... Oct. 14, 1905

22*Prof. ROBERT LUNAN WEIGHTON, Armstrong College, Newcastle-upon-Tyne ... ... April 2, 1898

MEMBERS (M.I.M.E.).

Marked * have paid life composition.

Date of Election and of Transfer.

1 Abbott, Henry Arnold, H.M. Inspector of Mines, 1, Highbury, West Jesmond, Newcastle-upon-Tyne ... Feb 13, 1904

2 Abel, Walter Robert, Scottish Provident Buildings, Mosley Street, Newcastle-upon-Tyne ... ... Dec. 8, 1906

3 Acutt, Sidney, The Barrett Gold-mining Company, Limited, Kaapoche Hoop, Transvaal ... ... Dec. 10, 1904

4 Adair, Hubert, Gillfoot, Egremont, S.O., Cumberland ... April 8, 1905

5 Adams, George Francis, Inspector of Mines in India, Dhanbaid, E.I. Railway, Manbhum District, Bengal, India ... ... Aug. 5, 1905

6 Adams, Henry Hopper, c/o H. Gilfillan, Jun., 108 and 109, Victoria Arcade, Auckland, New Zealand ... ... April 10, 1897

7 Adams, Phillip Francis Burnet, Surveyor-General for the Orange River Colony, Government Office, Bloemfontein, Orange River Colony, South Africa ... ... Oct. 12, 1901

8 Adamson, Thomas, Jherriah P.O., District Manbhoom, Bengal, India ... ... Feb. 10, 1894

9 Ainsworth, Herbert, P.O. Box 1553, Johannesburg, Transvaal .. .. Feb. 14, 1903

10 Ainsworth, John W., Bridgewater Offices, Walkden, Manchester ... ... Dec. 14, 1895

11 Aldridge, Walter Hull, Trail, British Columbia ... Feb. 8, 1908

12 Allan, John Frederick, c/o The Caucasus Copper Company, Limited, Bond Court House, Walbrook, London, E.C. ... ... A.M. Feb. 10, 1883
M. June 8, 1889

13 Allan, Philip, Mina de San Domingos, Mertola, Portugal June 10, 1905

14 Allison, J. J. C., Woodland Collieries, Butterknowle, S.O., County Durham ... ... A.M. Feb 13, 1886
M. June 8, 1889

15 Andersen, Carl, Sandy, Lincoln County, Nevada, U.S.A. Oct. 8, 1904

16 Anderson, Robert Hay, Apartado Postal 866, Mexico, D.F. Aug. 4, 1894

17 Anderson, Robert Simpson, Benwell View, Bentinck Road, Newcastle-upon-Tyne (*Member of Council*) ... ... S. June 9, 1883
A.M. Aug. 4, 1888
M. Aug. 3, 1889

18 Andrews, Arthur, 10, Ashwood Terrace, Sunderland ... Aug. 2, 1902

19 Andrews, Edward William, 4, Ashwood Terrace, Sunderland ... ... Aug. 4, 1906

20*Angwin, Benjamin, 3, Penlu Terrace, Tuckingmill, Camborne .. .. Nov. 24, 1894

21 Appleby, Harry Walton, c/o The St. John del Rey Mining Company, Limited, Villa Nova de Lima, Estado de Minas, Brazil, South America .. .. Oct. 8, 1898

22 Appleby, William Remsen, Minnesota School of Mines, The University of Minnesota, Minneapolis, Minnesota, U.S.A. April 14, 1894

23 Archer, Thomas, Mardale Parade, Gateshead-upon-Tyne July 2, 1872

24 Archer, William, Victoria Garesfield, Lintz Green, County Durham ... ... A. Aug. 6, 1892
M. Aug. 3, 1895

25 Armstrong, George Herbert Archibald, Castle View, Chester-le-Street ... ... April 8, 1905

26 Armstrong, Henry, Collingwood Buildings, Collingwood Street, Newcastle-upon-Tyne .. .. A.M. April 14, 1883
M. June 8, 1889

27 Armstrong, William, Elmfield Lodge, Gosforth, Newcastle-upon-Tyne (Past-President, *Member of Council*) S. April 7, 1867
M. Aug. 6, 1870

Date of Election and of Transfer.

28 Arnold, Thomas, Castle Buildings, Llanelly ... ... April 13, 1907
29 Ashmore, George Percy, South West African Company, Grootfontein, Swakopmund, Damaraland, South West Africa ... ... Feb. 13, 1897
30 Atherton, Thomas William Turner, c/o Miss Atherton, A.M. June 11, 1898
21, Handel Mansions, Handel Street, London, W.C. ... M. Dec. 10, 1898
31 Athron, Harold Vivian, Laburnum Cottage, Hindley, Wigan ... ... Feb. 13, 1904
32 Atkinson, Alfred, 40, Kings Chambers, Angel Street, A.M. April 13, 1901
Sheffield ... ... M. Dec. 12, 1908
33 Atkinson, John Boland, H.M. Inspector of Mines, 2, Devonshire Terrace, Newcastle-upon-Tyne (Vice-President, *Member of Council*) ... ... Oct. 11, 1902
34 Attwood, Alfred Lionel, Remolinos, por Pedrola, Provincia de Zaragoza, Spain ... ... Aug. 5, 1905
35 Aubrey, Richard Charles, 56, Fosse Road Central, Leicester Feb. 5, 1870

36 Baare, Fritz, Bochum, Westphalia, Germany ... ... Aug. 3, 1907
37 Bagnoli, Ugo, Orbetello, Italy ... ... Feb. 8, 1908
38 Bailes, Thomas, Jesmond Gardens, Newcastle-upon-Tyne Oct. 7, 1858
39 Bailey, Archibald Duncan, c/o S. G. Bailey and Company, Limited, Stafford Mills, Stroud, Gloucestershire ... Oct. 8, 1898
40 Bailey, Edward Trenholm, Penjaboengan, Padang, Sum- A.M. June 13, 1896
atra (West Coast), Netherlands East Indies ... ... M. June 12, 1897
41 Bain, Richard Donald, H.M. Inspector of Mines, Durham S. March 1, 1873
(Retiring Vice-President, *Member of Council*) ... M. Aug. 5, 1876
42 Bainbridge, Emerson, 47, Upper Grosvenor Street, S. Dec. 3, 1863
London, W. ... ... M. Aug. 1, 1868
43 Bainbridge, Emerson Muschamp, Shipcote, Newbiggin-by-the-Sea, S.O., Northumberland ... ... Feb. 8, 1902
44 Baldwin, Ivo William, Oakleigh, Ruardean, Mitcheldean, S.O., Gloucestershire ... ... Feb. 10, 1900
45 Barber, George Marriott, 42, Clapham Road, Bedford ... April 28, 1900
46 Barker, Matthew Wilson, Glyncoed, Laurie Park Road, Sydenham, London, S.E. ... ... April 8, 1893
47 Barnard, Robert, Great Chitcombe, Brede, Broad Oak, S.O., Sussex ... ... Dec. 11, 1897
48 Barrass, Matthew, Wheatley Hill Colliery Office, Thorn- S. Feb. 9, 1884
ley, S.O., County Durham ... ... A. Aug. 1, 1891
M. Dec. 8, 1900
49 Barrett, Charles Rollo, Whitehill Hall, Pelton Fell, S. Nov. 7, 1874
S.O., County Durham ... ... A.M. Aug. 7, 1880
M. Dec. 11, 1886
50 Barrow, William, Seaton Burn Colliery, Dudley, S.O., Northumberland ... ... Feb. 8, 1902
51*Bartholomew, Charles William, Blakesley Hall, near Towcester ... ... Dec. 4, 1875
52 Bates, Matthew John, Highbury, Stocksfield, S.O., Northumberland ... ... Feb. 11, 1905
53 Bates, Sidney, The Grange, Prudhoe, Ovingham, S.O., A. Feb. 8, 1890
Northumberland (*Member of Council*) ... M. June 8, 1895
54 Bates, Thomas L., Alfred Street, Waratah, New South Wales, Australia ... ... Feb. 12, 1898
55 Bateson, Walter Remington, Fairview, Goldington Avenue, Bedford ... ... Feb. 11, 1905
56 Batey, John Wright, Elmfield, Wylam, S.O., Northumberland ... ... Feb. 9, 1901
57 Bawden, William, Tolcarne House, Greta Street, Keswick Feb. 10, 1906
58 Bayliss, Ernest John, Inglenook, Beedell Avenue, Westcliff-on-Sea, Southend-on-Sea ... ... April 13, 1901
59 Beard, James Thom, 815, Sunset Avenue, North Park, Scranton, Pennsylvania, U.S.A. ... ... Feb. 14, 1903
60 Bekenn, Alexander Richard, Dundee Coal Company, Limited, Talana, Natal, South Africa ... ... Feb. 9, 1907

		Date of Election and of Transfer.
61	BELL, HAROLD PERCY, Pendlebury Colliery, Bentley, near Walsall	S. Aug. 2, 1902 A. Aug. 4, 1906 M. June 12, 1909
62	BELL, JOSEPH FENWICK, Orchard House, North Biddick, Washington, S.O., County Durham	April 12, 1902
63	BELL, REGINALD, Shildon Lodge Colliery, Darlington ...	Dec. 13, 1902
64	BELL, WALTER, c/o Pyman, Bell and Company, Hull ...	S. Oct. 8, 1889 M. Feb. 10, 1894
65	BELL, WILLIAM, Plashetts, S.O., Northumberland	S. Feb. 13, 1897 A. Aug. 6, 1904 M. Oct. 12, 1907
66	BELL, WILLIAM RALPH, Wearmouth Colliery, Sunderland	A. Oct. 13, 1894 M. Dec. 12, 1903
67	BEMENT, ALBURTO, 2114, Fisher Building, Chicago, Illinois, U.S.A.	Aug. 3, 1907
68	BENNETT, ALFRED HENRY, Bedminster, Easton, Kingswood and Parkfield Collieries, Limited, Easton Colliery, Bristol	A.M. April 10, 1886 M. June 8, 1889
69	BENNETT, HENRY, No. 5, Calle Sauz, La Minas de Rio Tinto, Provincia de Huelva, Spain	Dec. 9, 1899
70	BENSON, THOMAS WALTER, Collingwood Buildings, Collingwood Street, Newcastle-upon-Tyne (PAST-PRESIDENT, *Member of Council*)	Aug. 2, 1866
71	BERKLEY, CUTHBERT, Highfield House, Durham	Aug. 21, 1852
72	BERKLEY, RICHARD WILLIAM, Marley Hill, Swalwell, S.O., County Durham	S. Feb. 14, 1874 A.M. Aug. 7, 1880 M. June 8, 1889
73	BIGG-WITHER, HARRIS, The Mount, Gathurst, Wigan ...	Jan. 19, 1895
74	BIGGE, DENYS LEIGHTON SELBY, 27, Mosley Street, Newcastle-upon-Tyne	June 10, 1903
75	BIGLAND, HUBERT HALLAM, The Stones, Whitley Bay, S.O., Northumberland	Dec. 14, 1901
76	BIGLAND, JOHN, Henknowle, Bishop Auckland	June 3, 1857
77	BIRD, EDWARD ERSKINE, c/o George Elliot and Company, Limited, 16, Great George Street, Westminster, London, S.W.	A.M. Aug. 5, 1905 M. Dec. 14, 1907
78	BLACKETT, WILLIAM CUTHBERT, Acorn Close, Sacriston, Durham (VICE-PRESIDENT, *Member of Council*)	S. Nov. 4, 1876 A.M. Aug. 1, 1885 M. June 8, 1889
79	BLAIKLOCK, THOMAS HENDERSON, Bebside Colliery, Bebside, S.O., Northumberland	April 13, 1901
80	BLANDFORD, THOMAS, Main Street, Haltwhistle, S.O., Northumberland	S. Dec. 12, 1903 A. Aug. 3, 1907 M. June 12, 1909
81	BONNIWELL, PERCIVAL ORMOND, Cardeeth, 32, Rylett Crescent, Ravenscourt Park, London, W.	Dec. 12, 1903
82	BOOKLESS, JAMES, 14, Wilson Terrace, Broughton Moor, Maryport	Dec. 14, 1907
83	BORLASE, WILLIAM HENRY, Greenside Lodge, Glenridding, Penrith	Aug. 4, 1894
84	BOWEN, DAVID, The University, Leeds	April 3, 1909
85	BOWMAN, FRANCIS, Ouston Colliery Office, Chester-le-Street	A. June 8, 1895 M. Feb. 13, 1904
86*	BRACKEN, THOMAS WILSON, 40, Grey Street, Newcastle-upon-Tyne	Oct. 14, 1899
87	BRADFORD, GEORGE, Milbanke, Darlington	Oct. 11, 1890
88	BRAIDFORD, WILLIAM, Jun., South Garesfield Colliery, Lintz Green, County Durham	June 14, 1902
89	BRAMWELL, HUGH, Great Western Colliery, near Pontypridd	S. Oct. 4, 1879 A.M. Aug. 6, 1887 M. Aug. 3, 1889
90	BREAKELL, JOHN EDWIN, 14A, Mentone Mansions, Fulham Road, London, S.W.	April 25, 1896
91*	BRINELL, JOHAN AUGUST, Jernkontoret, Stockholm. Sweden	June 9, 1900

		Date of Election and of Transfer.
92	BROAD, WALLACE, British P.O. Box 225, Shanghai, China	April 28, 1900
93	BRODIGAN, CHARLES BERNARD, P.O. Box 3, Brakpan, Transvaal	Oct. 13, 1906
94	BROMLY, ALFRED HAMMOND, a/c Pacific Copper Company, Zihuatanejo, Guerrero, Mexico	Nov. 24, 1894
95	BROOKING, JOHN HENRY CHILCOTE, St. Helens Cable and Rubber Company, Limited, Warrington	Dec. 12, 1908
96	BROOME, GEORGE HERBERT, Westport, New Zealand ...	Oct. 9, 1897
97	BROUGH, THOMAS, New Seaham Colliery, Sunderland ...	S. Feb. 1, 1873 A.M. Aug. 2, 1879 M. June 8, 1889
98	BROWN, DOUGLAS PHILIP, The Old House, Sowerby, Thirsk	June 11, 1898
99	BROWN, JOHN CONNELL, Westport Coal Company, Limited, Denniston, New Zealand	Feb. 8, 1908
100	BROWN, ROBERT OUGHTON, Elswick Collieries, Newcastle-upon-Tyne	S. Oct. 8, 1892 A. Aug. 3, 1895 M. Oct. 12, 1901
101	BROWN, RALPH RICHARDSON, Pekin Syndicate, Limited, Honan, North China	Aug. 3, 1907
102	BROWN, W. FORSTER, Cefn Coed, Malpas, Newport, Monmouthshire	S. Aug. 6, 1887 M. Aug. 5, 1893
103	BROWNE, ROBERT JOHN, Bhowra Colliery, Jheria, E.I.R., Bengal, India	Feb. 10, 1906
104	BROWNING, WALTER JAMES, c/o Rio Tinto Company, Limited, Provincia de Huelva, Spain	Oct. 12, 1907
105	BRUCE, JOHN, Port Mulgrave, Hinderwell, S.O., Yorkshire	S. Feb. 14, 1874 A.M. Aug. 7, 1880 M. June 8, 1889
106	BRYHAM, WILLIAM, Bank House, Wigan	Dec. 8, 1900
107	BUCKLE, CHRISTOPHER ERNEST, Elmwood, Denville, Havant	Feb. 10, 1900
108	BULL, HENRY MATTHEWS, Bengal Coal Company, Limited, Rayhara, E. I. Railway, Palaman District, India ...	April 9, 1904
109	BULMAN, EDWARD HEMSLEY, The North Randfontein Gold-mining Company, Randfontein, Transvaal	Feb. 13, 1892
110	BULMAN, HARRISON FRANCIS, Leazes Hall, Burnopfield, S.O., County Durham	S. May 2, 1874 A.M. Aug. 6, 1881 M. June 8, 1889
111	BUNNING, CHARLES ZIETHEN, c/o The British Consular Agent, Panderma, Constantinople, Turkey	S. Dec. 6, 1873 A.M. Aug. 5, 1882 M. Oct. 8, 1887
112*	BURLS, HERBERT THOMAS, c/o Edward Riley and Harbord, 16, Victoria Street, Westminster, London, S.W. ...	Feb. 9, 1889
113*	BURN, FRANK HAWTHORN, 9, Sandhill, Newcastle-upon-Tyne. *Transactions* sent to Pattishall House, Towcester ...	S. Feb. 9, 1889 A. Aug. 4, 1894 M. Aug. 3, 1895
114	BURNE, CECIL ALFRED, Ranelagh Cottage, High Wycombe	S. Aug. 4, 1894 M. Aug. 3, 1901
115	BURNETT, CUTHBERT, Grange Iron Works, Durham ...	June 8, 1895
116*	BURNS, DAVID, Vallum View, Belle Vue, Carlisle	May 5, 1877
117	BURTON, GEORGE AUGUSTUS, Highfield, Nunthorpe, S.O., Yorkshire	Dec. 9, 1905
118	BUTTERS, CHARLES, 220, Crocker Building, San Francisco, California, U.S.A.	Feb. 10, 1894
119	CAREY, JOSEPH MACLEOD, H.M. Inspector of Mines, Durham	April 4, 1903
120	CARNEGIE, ALFRED QUINTIN, 31, Manor House Road, Newcastle-upon-Tyne	Oct. 11, 1902
121	CARNES, CHARLES SPEARMAN, Marsden Hall, South Shields (*Member of Council*)	Aug. 1, 1891
122	CARROLL, JAMES, Brilliant and St. George Gold-mine, Charters Towers, Queensland, Australia	Dec. 10, 1898
123	CARROLL, MILES T., Tananarive, Madagascar	Feb. 10, 1906

			Date of Election and of Transfer.
124	CASEBOURNE, AMBROSE CUBITT, 3, St. Nicholas' Buildings, Newcastle-upon-Tyne		June 9, 1906
125	CASEBOURNE, SAMUEL WARD JACKSON, Cleveland Terrace, Darlington		Dec. 10, 1904
126	CASSON, WILLIAM WALTER, St. Bees, S.O., Cumberland ...		Aug. 5, 1905
127	CHAMBERS, ARTHUR LEO, c/o The Messina Transvaal Development Company, Grenfell Camp, Pietersburg, Transvaal		Feb. 8, 1902
128	CHAMBERS, DAVID MACDONALD, 23, St. Mary's Mansions, Paddington, London, W.	A.M.	Oct. 8, 1904 M. June 12, 1909
129	CHAMBERS, J. S., 5, Joukovskaja, St. Petersburg, Russia		Oct. 10, 1896
130	CHAMBERS, R. E., Nova Scotia Steel and Coal Company, Limited, New Glasgow, Nova Scotia		June 9, 1900
131	CHANNING, J. PARKE, 11, Broadway, New York City, U.S.A.		April 25, 1896
132	CHAPMAN, JAMES, 13, Queens Road, Erith, S.O., Kent ...		Feb. 13, 1909
133	CHAPMAN, JOHN ABEL, 56, Bewick Road, Gateshead-upon-Tyne		June 8, 1907
134*	CHAPPEL, WALTER RICHARD HAIGHTON, Ipok, Perak, Malay Peninsula		Feb. 14, 1903
135	CHARLETON, ARTHUR GEORGE, 5, Avonmore Road, Kensington, London, W.		Aug. 6, 1892
136	CHARLTON, WILLIAM, Guisborough		Feb. 12, 1898
137	CHARLTON, WILLIAM JOHN, Ashington Colliery, Morpeth		April 25, 1896
138	CHEESMAN, EDWARD TAYLOR, Claravale Colliery, Ryton, S.O., County Durham	A. M.	Aug. 2, 1890 Aug. 6, 1892
139	CHEESMAN, HERBERT, Hartlepool		Aug. 6, 1892
140	CHEESMAN, ISAAC TAYLOR, Throckley Colliery, Newburn, S.O., Northumberland		Feb. 1, 1873
141	CHEESMAN, NICHOLAS, Blucher Pit, Newburn, S.O., Northumberland		Dec. 8, 1900
142	CHICKEN, BOURN RUSSELL, 212, Osborne Road, Jesmond, Newcastle-upon-Tyne		Dec. 12, 1903
143	CHILDE, HENRY SLADE, 59, Westgate, Wakefield	A.M. M.	Feb 12, 1887 Aug. 3. 1889
144	CHURCH, ROBERT WILLIAM, Bokaro and Ramgur, Limited, Hazaribagh P.O., Chota-Nagpur, India	S. A. M.	Dec. 9, 1905 Aug. 3, 1907 Oct. 12, 1907
145	CLAGHORN, CLARENCE R., Northwestern Improvement Company, Headquarters Building, Tacoma, Washington, U.S.A.		Aug. 5, 1899
146	CLARK, HENRY, Inglenook, Norton, Stockton-upon-Tees ...		April 8, 1899
147	CLARK, ROBERT, Rothalie, Fife Road, Darlington		Feb. 15, 1896
148	CLARK, ROBERT BLENKINSOP, Springwell Colliery, Gateshead-upon-Tyne	S. M.	May 3, 1873 Aug. 4, 1877
149	CLARK, WILLIAM HENRY, Craigengower, Grange-over-Sands, S.O., Lancashire		April 28, 1900
150	CLAUDET, ARTHUR CROZIER, 6 and 7, Coleman Street, London, E.C.		Aug. 3, 1895
151	CLIFFORD, WILLIAM, Jeannette, Pennsylvania, U.S.A. ...		Feb. 9, 1895
152	CLOUGH, JAMES, Bomarsund House, Bomarsund, Bedlington, S.O., Northumberland	S. A.M. M.	April 5, 1873 Aug. 3, 1878 June 8, 1889
153	COCHRANE, BRODIE, Low Gosforth House, Newcastle-upon-Tyne		Dec. 6, 1866
154	COCKBURN, EVAN, The New River Company, Parral, Fayette County, West Virginia, U.S.A.	A. M.	Aug. 5, 1893 Dec. 8, 1906
155	COLLEY, JOHN, Indwe Railway, Collieries and Land Company, Limited, P.O. Box 4, Indwe, Cape Colony, South Africa		Feb. 9, 1901
156*	COLLINS, HUGH BROWN, Auchinbothie Estate Office, Kilmacolm, S.O., Renfrewshire		April 14, 1894
157	COLLINS, VICTOR BUYERS, Lewis Street, Islington, *via* Newcastle, New South Wales, Australia		June 11, 1904

Date of Election and of Transfer.

158 Colquhoun, Thomas Grant, The Durban Navigation Collieries, Limited, Dannhauser, Natal, South Africa ... ... Dec. 14, 1898

159 Commans, Robert Edden, 6, Queen Street Place, London, E.C. ... ... Nov. 24, 1894

160 Comstock, Charles Worthington, Boston Building, Denver, Colorado, U.S.A. ... ... June 10, 1905

161 Cook, Joseph, Washington Iron Works, Washington, S.O., County Durham ... ... May 8, 1869

162 Cook, Joseph, Jun., Washington Iron Works, Washington, S.O., County Durham ... ... Oct. 9, 1897

163 Cook, James Falshaw, Washington Iron Works, Washington, S.O., County Durham ... ... Feb. 12, 1898

164 Cook, John Watson, Binchester Hall, Bishop Auckland... Oct. 14, 1893

165 Cooke, Henry Moore Annesley, The Champion Reef Gold-mining Company of India, Limited, Champion Reefs P.O., Mysore State, South India ... ... Dec. 12, 1896

166*Coppée, Evence, 71, Boulevard d'Anderlecht, Brussels, Belgium ... ... Feb. 9, 1907

167 Corbett, Vincent, Blackett Colliery, Haltwhistle, S.O., Northumberland ... ... A. June 11, 1898 M. Feb. 13, 1904

168 Corbett, Vincent Charles Stuart Wortley, Chilton Moor, Fence Houses ... ... Sept 3, 1870

169 Corlett, George Stephen, Wigan ... ... Dec. 12, 1891

170 Corning, Christopher Robert, 36, Wall Street, New York City, U.S.A. ... ... June 14, 1902

171 Coste, Eugene, 210, Poplar Plains Road, Toronto, Ontario, Canada... ... ... June 9, 1900

172 Coulson, Frank, Shamrock House, Durham (*Member of Council*) ... ... S. Aug. 1, 1868 M. Aug. 2, 1873

173 Couves, Harry Augustus, 64, Osborne Road, Newcastle-upon-Tyne ... ... Feb. 10, 1906

174 Cowell, Edward, Horden Colliery, Horden, Sunderland ... A. Oct. 8, 1904 M. June 20, 1908

175 Cowell, Joseph Stanley, Vane House, Seaham Harbour, S.O., County Durham ... ... Dec. 12, 1908

176 Cowper-Coles, Sherard Osborn, Grosvenor Mansions, Victoria Street, Westminster, London, S.W. ... ... Dec. 9, 1899

177 Cox, John H., 10, St. George's Square, Sunderland ... ... Feb. 6, 1875

178 Craster, Walter Spencer, P.O. Box 216, Kopje, Salisbury, Rhodesia, South Africa ... ... Dec. 8, 1900

179 Craven, Robert Henry, The Libiola Copper-mining Company, Limited, Sestri Levante, Italy ... ... Feb. 11, 1905

180 Crawford, James Mill, Denehurst, Ferry Hill ... ... Feb. 14, 1903

181 Crofton, Charles Arthur, Wansbeck Colliery Company, Limited, Morpeth ... ... S. Dec. 10, 1898 A. Aug. 1, 1903 M. Dec. 14, 1907

182 Crookston, Andrew White, 188, St. Vincent Street, Glasgow ... ... Dec. 14, 1895

183 Crosby, Arthur, Douglas Colliery, Limited, Balmoral, Transvaal ... ... A.M. Aug. 7, 1897 M. April 12, 1902

184 Cross, William Haslam, 77, King Street, Manchester ... Feb. 8, 1902

185 Croudace, Francis Henry Lambton, The Lodge, Lambton, Newcastle, New South Wales, Australia ... ... June 8, 1907

186 Croudace, Sydney, New Lambton, Newcastle, New South Wales, Australia ... ... June 8, 1907

187 Cruz y Diaz, Emiliano de la, Ingeniero Director de los Minas de Ribas, Provincia de Gerona, Spain ... ... June 14, 1902

188 Cummings, John, Hamsterley Colliery, Ebchester, S.O., County Durham ... ... A. Aug. 2, 1902 M. Dec. 14, 1907

189 Cunningham, John Allan, P.O. Box 59, Dundee, Natal, South Africa ... ... Dec. 8, 1906

190 Currie, Walter, P.O. Box 220, Bulawayo, Rhodesia, South Africa ... ... April 25, 1896

		Date of Election and of Transfer.
191	CURRY, GEORGE ALEXANDER, Thornley House, Thornley, S.O., County Durham	Oct. 12, 1907
192	CURRY, MICHAEL, Cornsay Colliery, Durham	Aug. 6, 1898
193	CUTTEN, WILLIAM HENRY	Aug. 5, 1899
194	DAGGAR HENRY JAMES, Afton, Church Street, Marrickville, New South Wales, Australia	Oct. 12, 1901
195	DAGLISH, WILLIAM CHARLTON, Littleburn Colliery, near Durham	Dec. 12, 1896
196	DAKERS, WILLIAM ROBSON, Tudhoe Colliery, Spennymoor	A.M. Oct. 14, 1882 M. Aug. 3, 1889
197	DAN, TAKUMA, Mitsui Mining Company, 1, Suruga-cho, Nihonbashi-ku, Tokyo, Japan	April 14, 1894
198	DANIEL, PETER FRANCIS, Greymouth, New Zealand	April 8, 1893
199	DARLING, FENWICK, Sowerby Grange, Thirsk	Nov. 6, 1875
200	DARLINGTON, JAMES, Black Park Colliery, Ruabon	S. Nov. 7, 1874 M. Aug. 4, 1877
201	DAVIDSON, ALLAN ARTHUR, Casilla 6, Valparaiso, Chile, South America	April 13, 1907
202	DAVIDSON, CHRISTOPHER CUNNION, Hardheads, Egremont, S.O., Cumberland	Oct. 10, 1908
203	DAVIES, DAVID, Cowell House, Llanelly	Dec. 9, 1899
204	DAVIES, WILLIAM STEPHEN, Tredegar Iron and Coal Company, Park Hill, Tredegar	Feb. 14, 1903
205	DAVIS, CHARLES HENRY, South Yarmouth, Massachusetts, U.S.A.	Oct. 13, 1900
206	DAW, ALBERT WILLIAM, 11, Queen Victoria Street, London, E.C.	June 12, 1897
207	DAW, JOHN W., Walreddon Manor, Tavistock	Dec. 14, 1895
208	DEAN, HARRY, Eastbourne Gardens, Whitley Bay, S.O., Northumberland	June 10, 1905
209	DEAN, JOHN, The Wigan Coal and Iron Company, Limited, Wigan	Feb. 13, 1904
210	DEAN, SAMUEL, Gallup Southwestern Coal Company, Gallup, New Mexico, U.S.A.	Oct. 13, 1906
211	DEES, JAMES GIBSON, Floraville, Whitehaven	Oct. 13, 1883
212	DENNY, GEORGE A., 564, Salisbury House, London, E.C.	Dec. 8, 1894
213	DICK, WILLIAM, 5, Avonmore Gardens, West Kensington, London, W.	April 13, 1907
214	DICKINSON, ARTHUR, 353, Mansion House Chambers, 11, Queen Victoria Street, London, E.C.	April 14, 1894
215	DIETZSCH, FERDINAND, 652-655, Salisbury House, London Wall, London, E.C.	Aug. 5, 1899
216*	DINGWALL, WILLIAM BURLISTON-ABIGAIL, Apartado 13, Matehuala, San Luis Potosi, Mexico	Aug. 4, 1900
217	DITMAS, FRANCIS IVAN LESLIE, Chindwara, Central Provinces, India	A. June 11, 1898 M. June 14, 1902
218	DIVES, ROBERT, Durban, Natal, South Africa	Feb. 8, 1902
219	DIXON, CHARLES WILLIS, Westport Coal Company, Limited, Denniston, New Zealand	Feb. 8, 1908
220	DIXON, DAVID WATSON, Lumpsey Mines, Brotton, S.O., Yorkshire	Nov. 2, 1872
221	DIXON, GEORGE, c/o Bird and Company, 100-101, Clive Street, Calcutta, India	S. June 13, 1896 A. Aug. 6, 1904 M. Dec. 8, 1906
222	DIXON, JONATHAN, Westport Coal Company, Limited, Denniston, New Zealand	Oct. 13, 1894
223	DIXON, JOSEPH ARMSTRONG, Shilbottle Colliery, Lesbury, S.O., Northumberland	Dec. 14, 1901
224*	DIXON, JAMES STEDMAN, Fairleigh, Bothwell, Glasgow	Aug. 3, 1878
225	DIXON, WILLIAM, Cleator, S.O., Cumberland	April 10, 1897
226	DOBB, THOMAS GILBERT, Brick House, Westleigh, Leigh	Dec. 8, 1894
227	DODD, BENJAMIN, Bearpark Colliery, Durham (*Member of Council*)	S. May 3, 1866 M. Aug. 1, 1868

		Date of Election and of Transfer.
228	Dodd, Michael, Rand Club, Johannesburg, Transvaal ...	S. Dec. 4, 1875 A.M. Aug. 7, 1880 M. June 8, 1889
229	Doise, Sosthenes, 1 bis, rue du Souvenir, Courbevoie (Seine), France	June 14, 1902
230	Donald, William E., 47, Lyons Terrace, Four Lane Ends, Hetton-le-Hole, S.O., County Durham	Oct. 14, 1905
231*	Donkin, William, Mines Department, Macequece, Portuguese East Africa	S. Sept. 2, 1876 A.M. Aug. 1, 1885 M. June 8, 1889
232	Dormand, Ralph Brown, Cambois House, Cambois, Blyth	A. Dec. 9, 1893 M. Aug. 3, 1901
233	Douglas, Arthur Stanley, Low Beechburn Colliery Office, Crook, S.O., County Durham	Feb. 13, 1904
234*	Douglas, Charles Prattman, Thornbeck Hill, Carmel Road, Darlington	March 6, 1869
235	Douglas, James, 99, John Street, New York City, U.S.A.	Oct. 14, 1899
236	Douglas, Matthew Heckels, Enfield Villa, Saltwell Park, Gateshead-upon-Tyne	A.M. Aug. 2, 1879 M. Aug. 3, 1889
237	Douglas, Thomas, The Garth, Darlington (Past-President, *Member of Council*)	Aug. 21, 1852
238	Draper, William, Silksworth Colliery, Sunderland ...	A. Dec. 14, 1889 M. Dec. 12, 1903
239	Duncan, William Shaw	Oct. 14, 1905
240	Dunkerton, Ernest Charles, 53, Grosvenor Place, Newcastle-upon-Tyne	Feb. 9, 1907
241	Dunn, George Victor Septimus 7, St. James' Buildings, William Street, Melbourne, Victoria, Australia ...	June 20, 1908
242	Eastlake, Arthur William, Grosmont, Palace Road, Streatham Hill, London, S.W.	June 11, 1892
243	Ede, Henry Edward, 10, Violet Bank Road, Nether Edge, Sheffield	July 14, 1896
244	Eden, Charles Hamilton, Glyn-Dderwen, Blackpill, S.O., Glamorgan	June 14, 1890
245	Edwards, Edward, Maindy Pit, Ocean Collieries, Ton Pentre, Pentre, Pontypridd	Feb. 9, 1895
246	Edwards, Herbert Francis, 104, Stanwell Road, Penarth	Oct. 12, 1901
247	Edwards, Owain Tudor, Fedwhir, Aberdare	Aug. 4, 1906
248	Eliet, Francis Constant André Benoni Elié du, Compagnie Lyonnaise de Madagascar, à Ambositra, Madagascar	Aug. 3, 1901
249*	Elsdon, Robert William Barrow	April 13, 1901
250	Eltringham, George, Eltringham Colliery, Prudhoe, Ovingham, S.O., Northumberland	A. Dec. 8, 1894 M. Aug. 2, 1902
251	Elwen, Thomas Lee, Brandon Colliery, S.O., County Durham	Oct. 13 1888
252	Embleton, Henry Cawood, Central Bank Chambers, Leeds	April 14, 1894
253	Englesqueville, René d', 7, rue Henri Martin, Paris, France	Feb. 8, 1908
254	English, John, Broomfield, Chopwell, Ebchester, S.O., County Durham	Dec. 9, 1899
255	English, William, North Walbottle Colliery, Newburn, S.O., Northumberland	Dec. 14, 1907
256	Epton, William Martin, M. Syndicate, Golden Valley, Rhodesia, South Africa	Oct. 12, 1895
257	Esmarch, Cecil August, 19, Wentworth Place, Newcastle-upon-Tyne	April 9, 1904
258	Etherington, John, 39A, King William Street, London Bridge, London, E.C.	Dec. 9, 1893
259	Evans, Lewis, Rand Club, Johannesburg, Transvaal ...	Oct. 14, 1893
260	Everard, John Breedon, 6, Millstone Lane, Leicester	March 6, 1869

Date of Election and of Transfer.

261 FAIRLEY, JAMES, Craghead and Holmside Collieries, Chester-le-Street ... ... A.M. Aug. 7, 1880
M. Aug. 3, 1889

262 FANGEN, STENER AUGUST, Aktieselskabet Norsk Malmexport, Kaljord pr. Kvitnes, Vesteraalen, Norway ... April 9, 1904

263 FAWCETT, EDWARD STOKER, Battle Hill House, Walker, Newcastle-upon-Tyne ... ... A. June 11, 1892
M. Aug. 6, 1904

264*FENWICK, BARNABAS, 66, Manor House Road, Newcastle-upon-Tyne ... ... Aug. 2, 1866

265 FERGIE, CHARLES, P.O. Box 64, Sydney, Nova Scotia ... Dec. 9, 1893

266 FERGIE, GEORGE, Copiapó, Chile, South America ... Dec. 12, 1908

267 FERGUSON, DAVID, 140, Hyndland Road, Kelvinside, Glasgow A.M. Dec. 8, 1883
M. Aug. 3, 1889

268 FERGUSON, JAMES, P.O. Box 98, Johannesburg, Transvaal Dec. 12, 1896

269 FÈVRE, LUCIEN FRANCIS, 1, place Possoz (XVI[e]), Paris, France ... ... Feb. 8, 1908

270 FIELD, EDWIN RICHARD, Daylesford, Victoria, Australia ... April 28, 1900

271 FIGARI, ALBERTO, Apartado 516, Lima, Peru, South America ... ... April 25, 1896

272 FISHBACK, MARTIN, Guaranty Trust Building, El Paso, Texas, U.S.A. ... ... April 12, 1902

273 FISHER, EDWARD ROBERT, Wansbeck, Ammanford, S.O., Carmarthenshire ... ... A.M. Aug. 2, 1884
M. Aug. 3, 1889

274 FISHER, HENRY HERBERT, Calle Sucre, 1841, Belgrano, near Buenos Aires, Argentine Republic, South America Oct. 8, 1904

275 FLEMING, HENRY STUART, 1, Broadway, New York City, U.S.A. ... ... June 10, 1905

276 FLETCHER, JAMES, State Colliery, Seddonville, New Zealand Oct. 14, 1905

277 FLETCHER, LANCELOT HOLSTOCK, Allerdale Coal Company, Limited, Colliery Office, Workington ... ... A.M. April 14, 1888
M. June 8, 1889

278*FLETCHER, WALTER, The Hollins, Bolton ... ... Dec. 14, 1895

279 FLINT, JOHN, Radcliffe House, Acklington, S.O., Northumberland... ... ... Jan. 19, 1895

280 FOGG, LEWIS WARNER, Uniontown, Fayette County, Pensylvania, U.S.A. ... ... Feb. 8, 1908

281 FORD, MARK, Washington Colliery, Washington Station, S.O., County Durham (*Member of Council*) ... ... Aug. 3, 1895

282 FORD, STANLEY HORACE, 5, Osborne Terrace, Ashley Down Road, Bristol ... ... June 10, 1893

283 FORSTER, ALFRED LLEWELLYN, Newcastle and Gateshead Water Company, Engineer's Office, Pilgrim Street, Newcastle-upon-Tyne ... ... June 8, 1901

284 FORSTER, JOHN HENRY BACON, Whitworth House, Spennymoor ... ... S. Nov. 24, 1894
A. Aug. 7, 1897
M. Feb. 10, 1900

285 FORSTER, JOSEPH WILLIAM, P.O. Box 56, East Rand, Transvaal ... ... Feb. 13, 1904

286 FORSTER, RICHARD PERCIVAL, Mount Pleasant, Spennymoor Feb. 14, 1903

287 FORSTER, THOMAS EMERSON, 3, Eldon Square, Newcastle-upon-Tyne (PRESIDENT, *Member of Council*) ... ... A.M. S. Oct. 7, 1876
Aug. 1, 1885
M. June 8, 1889

288 FOX, GEORGE CHARLES, P.O. Box 1030, Johannesburg, Transvaal ... ... Feb. 14, 1903

289 FRYAR, JOHN WILLIAM, Eastwood Collieries, near Nottingham ... ... A. June 14, 1890
M. June 12, 1897

290 FRYAR, MARK, Denby Colliery, Derby ... ... S. Oct. 7, 1876
A.M. Aug. 4, 1883
M. June 8, 1889

291 FRYER, GEORGE KELLETT, Bleak House, Broughton Moor, Maryport ... ... Dec. 14, 1901

292 FUTERS, THOMAS CAMPBELL, 17, Balmoral Gardens, Monkseaton, Whitley Bay, S.O., Northumberland ... ... Aug. 6, 1904

293 GALLOWAY, THOMAS LINDSAY, 175, West George Street, Glasgow ... ... Sept. 2, 1876

		Date of Election and of Transfer.
294	GALLOWAY, WILLIAM, Cardiff	April 23, 1887
295	GASCON Y MIRAMON, ANTONIO, Carranza, 8, Madrid, Spain	Aug. 2, 1902
296	GIBSON, JAMES, c/o W. E. Robarts, Acutts Arcade, Durban, Natal, South Africa	A.M. Dec. 9, 1899 M. Feb. 13, 1904
297	GIFFORD, HENRY J., 51, St. John's Road, Clifton, B.O., Bristol	Oct 14, 1893
298	GILLMAN, GUSTAVE, Aguilas, Provincia de Murcia, Spain	Aug. 2, 1902
299	GIPPS, F. G. DE VISME, Irvinebank, North Queensland, Australia	April 25, 1896
300	GLASS, ROBERT WILLIAM, Axwell Park Colliery, Swalwell, S.O., County Durham	S. June 10, 1899 A. Aug. 1, 1903 M. Oct. 12, 1907
301	GONINON, RICHARD, Menzies Consolidated Gold-mines, Limited, Menzies, Western Australia	June 10, 1906
302	GOODWIN, ROBERT HARVEY, Karabournou Mercury-mine, c/o C. Whittall and Company, Smyrna, Turkey ...	Oct. 13, 1900
303	GOODWIN, WILLIAM LAWTON, School of Mining, Kingston, Ontario, Canada	Feb. 11, 1899
304	GORE, HENRY, Victorian Gold Estates, Limited, National Mutual Buildings, 395, Collins Street, Melbourne, Victoria, Australia	April 28, 1900
305	GOUGH, GEORGE HENRY, Singareni Collieries, Yellandu (Deccan), India	Aug. 4, 1900
306	GOULDIE, JOSEPH, 48, Standard Bank Chambers, Johannesburg, Transvaal	Aug. 5, 1893
307	GOWLAND, JOSEPH EDWIN, Mina Caridad, Aznalcollar, Sevilla, Spain	June 11, 1904
308	GRAHAM, EDWARD, Jun., Bedlington Colliery, Bedlington, S.O., Northumberland	Aug. 1, 1896
309	GRAVE, PERCY, c/o Suriana Mining and Smelting Company, Achotla, Campo Merado, Estado de Guerrero, Mexico	Oct. 13, 1900
310	GREAVES, J. O., Westgate, Wakefield...	Aug. 7, 1862
311	GREEN, EDWIN HENRY, P.O. Box 1978, Johannesburg, Transvaal	Aug. 1, 1903
312	GREEN, JOSEPH, Crag House, Ferry Hill	Dec. 13, 1902
313	GREEN, JOHN DAMPIER, P.O. Box 340, Johannesburg, Transvaal	A.M. Dec. 14, 1901 M. Aug. 2, 1902
314	GREENER, HERBERT, Swallowhurst, Thorne, Doncaster	Feb. 13, 1909
315	GREENER, THOMAS YOUNG, West Lodge, Crook, S.O., County Durham (VICE-PRESIDENT, *Member of Council*)	S. July 2, 1872 A.M. Aug. 2, 1879 M. June 8, 1889
316	GREENWELL, ALLAN, 30 and 31, Furnival Street, Holborn, London, E.C....	Aug. 4, 1900
317	GREENWELL, ALAN LEONARD STAPYLTON, Eldon Colliery, Bishop Auckland	S. Oct. 8, 1898 A. Aug. 5, 1905 M. Dec. 14, 1907
318	GREENWELL, GEORGE CLEMENTSON, Poynton, Stockport ...	S. March 6, 1869 M. Aug. 3, 1872
319	GRESLEY, WILLIAM STUKELEY, Avenue Road, Duffield, Derby	A.M. Oct. 5, 1878 M. Aug. 3, 1889
320	GRIBBEN, EDWARD	April 9, 1904
321	GRIFFITH, NATHANIEL MAURICE	S. Nov. 24, 1894 M. Feb. 11, 1899
322	GRIFFITH, THOMAS, Maes Gwyn, Cymmer, Porth, Pontypridd	April 9, 1904
323	GRIFFITH, WILLIAM, Waterloo House, Aberystwyth ...	Dec. 9, 1893
324	GRIFFITHS, JOHN NORTON, 62, London Wall, London, E.C.	April 11, 1908
325*	GRUNDY, JAMES, 8, Grosvenor Gardens, Cricklewood, London, N.W.	June 13, 1896
326	GULLACHSEN, BERENT CONRAD, 2, South Parade, Whitley Bay, S.O., Northumberland	S. April 8, 1905 M. Aug. 3, 1907
327	GUMMERSON, JAMES M., 35, Birkbeck Road, Acton, London, W.	A.M. June 10, 1899 M. Dec. 12, 1903

		Date of Election and of Transfer.
328	HADDOCK, WILLIAM THOMAS, The Sheba Gold-mining Company, Limited, Eureka, Transvaal	S. Oct. 7, 1876 A.M. Aug. 1, 1885 M. June 8, 1889
329	HALBAUM, HENRY WALLACE GREGORY, Horden Colliery, Horden, Sunderland	April 8, 1899
330	HALL, FREDERICK, Fernleigh, Highfield, Workington ...	Oct. 14, 1893
331	HALL, JOHN CHARLES, Black Boy Colliery, Bishop Auckland	A. Dec. 14, 1889 M. Aug. 3, 1895
332	HALL, JOSEPH JOHN, Ashington Colliery, Morpeth ...	Dec. 10, 1904
333	HALL, MATTHIAS STOKOE, Springwell Villa, Bishop Auckland	Feb. 14, 1874
334	HALL, ROBERT WILLIAM, Fairlawn, Leeholme, Bishop Auckland	A. Dec. 13, 1902 M. June 8, 1907
335	HALL, TOM, Ryhope Colliery, Sunderland	June 8, 1889
336	HALLAS, GEORGE HENRY, Claremont, Huyton, Liverpool ...	S. Oct. 7, 1876 A.M. Aug. 4, 1883 M. June 8, 1889
337	HALLIMOND, WILLIAM TASKER, Geldenhuis Deep, Limited, P.O. Box 54, Cleveland, Transvaal	Dec. 14, 1889
338	HAMILTON, EDWARD, Rig Wood, Saltburn-by-the-Sea ...	S. Nov. 1, 1873 A.M. Aug. 2, 1879 M. June 8, 1889
339	HAMILTON, JAMES, Blackhills Road, Horden, Sunderland ...	Oct. 10, 1908
340	HANCE, HENRY MALKIN, Nagpur, Central Provinces, India	Oct. 12, 1907
341*	HANCOCK, HENRY LIPSON, Wallaroo and Moonta Mining and Smelting Company, Limited, Moonta Mines, South Australia	Dec. 14, 1895
342	HANCOCK, HENRY RICHARD, Holwell, Whitchurch, Tavistock	A.M. Aug. 4, 1894 M. Nov. 24, 1894
343	HANN, ROBERT, Jun., 8, South View Terrace, South Shields	Oct. 14, 1895
344	HANNAH, DAVID, Brynderwen, Ferndale, Pontypridd ...	Feb. 9, 1895
345	HARE, GEORGE, Seghill Colliery, Seghill, Dudley, S.O., Northumberland	A. Feb. 12, 1898 M. Dec. 14, 1907
346	HARE, SAMUEL, Howlish Hall, Bishop Auckland (*Member of Council*)	S. Aug. 2, 1879 M. Aug. 1, 1891
347	HARLE, PETER, Page Bank Colliery, County Durham ...	Oct. 8, 1892
348	HARLE, RICHARD, Browney Colliery, Durham ...	April 7, 1877
349	HARLE, ROBERT ALFRED, Alma Cottage, Campbells Hill, West Maitland, New South Wales, Australia	A. April 14, 1894 M. Oct. 12, 1901
350	HARLE, WILLIAM, Bowburn Colliery, Coxhoe, S.O., County Durham	Dec. 12, 1908
351	HARRIS, DAVID, Elands Laagte Collieries, Limited, Elands Laagte, Natal, South Africa	A.M. June 12, 1897 M. April 13, 1901
352	HARRIS, HOWARD, P.O. Box 2462, Johannesburg, Transvaal	Aug. 7, 1897
353	HARRIS, WILLIAM SCORER, Kibblesworth, Gateshead-upon-Tyne	S. Feb. 14, 1874 A.M. Aug. 7, 1880 M. June 8, 1889
354	HARRISON, CHARLES AUGUSTUS, North Eastern Railway, Newcastle-upon-Tyne	June 21, 1894
355	HARRISON, WILLIAM B., Brownhills Collieries, near Walsall	April 6, 1867
356	HASELDEN, ARTHUR, Linares, Provincia de Jaen, Spain ...	A.M. Dec. 11, 1897 M. April 2, 1898
357*	HAWKER, EDWARD WILLIAM, Gladstone Chambers, Pirie Street, Adelaide, South Australia	Oct. 12, 1895
358	HAWKINS, THOMAS SPEAR, Millpond House, Hayle, S.O., Cornwall	Aug. 6, 1904
359	HAWXHURST, ROBERT, Jun., Casillas 855-856, Antofagasta, Chile, South America	Feb. 13, 1909
360	HEADS, ROBERT WILLIAM, 85, Raffles Chambers, Singapore	June 14, 1902
361	HEDLEY, ARTHUR MORTON, Blaydon Burn, Blaydon-upon-Tyne, S.O., County Durham (*Member of Council*) ...	A. Nov. 24, 1894 M. Dec. 12, 1903
362	HEDLEY, SEPTIMUS H., Langholme, Roker, Sunderland ...	S. Feb. 15, 1879 A.M. Aug. 1, 1885 M. Aug. 3, 1889

		Date of Election and of Transfer.
363	HEINZE, F. AUGUSTUS, Butte, Montana, U.S.A.	Dec. 11, 1897
364	HEISE, FRITZ, Hernerstrasse, 45, Bochum, Germany ...	Aug. 5, 1905
365	HENDERSON, CHARLES, Cowpen Colliery Office, Blyth ...	Dec. 9, 1899
366	HENDY, JOHN CARY BAKER, Etherley, *via* Darlington ...	Oct. 14, 1893
367	HENRIKSEN, GUDBRAND, Inspector of Mines, Fjösanger, near Bergen, Norway	Aug. 6, 1904
368	HERDMAN, WILLIAM, St. John's Chapel, S.O., County Durham	April 11, 1908
369	HERRMANN, HENRY J. A., c/o John Carnegie, 5/6, Bucklersbury, London, E.C.	Dec. 10, 1898
370	HESLOP, CHRISTOPHER, Woodside, Marske Mill Lane, Saltburn-by-the-Sea	S. Feb. 1, 1868 M. Aug. 2, 1873
371	HESLOP, GRAINGER, North Moor House, Sunderland ...	Oct. 5, 1872
372	HESLOP, MICHAEL, Rough Lea Colliery, Willington, S.O., County Durham	A. Feb. 10, 1894 M. June 21, 1894
373	HESLOP, SEPTIMUS, New Beerbhoom Coal Company, Limited, Asansol, Bengal, India	Oct. 12, 1895
374	HESLOP, THOMAS, Randolph Colliery, Evenwood, Bishop Auckland	S. Oct. 2, 1880 A.M. Aug. 4, 1888 M. Aug. 3, 1889
375	HESLOP, WILLIAM TAYLOR, St. George's Colliery, Hatting Spruit, Natal, South Africa	Aug. 3, 1895
376	HEWITSON, THOMAS, Associated Northern Company, Kalgoorlie, Western Australia	Dec. 9, 1899
377*	HEWITT, GEORGE COLTHURST, Serridge House, Coalpit Heath, Bristol	June 3, 1871
378	HEWLETT, ALFRED, Haseley Manor, Warwick	March 7, 1861
379	HEWLETT, ALFRED, The Cossall Colliery Company, Limited, Cossall, near Nottingham	June 20, 1908
380	HEWLETT, ERNE, Ammanford Colliery Company, Limited, Ammanford, S.O., Carmarthenshire	Oct. 10, 1896
381	HEWLETT, HOWE, Clock Face Colliery, Sutton Oak, St. Helens	Feb. 13, 1904
382	HIGSON, JACOB, Crown Buildings, 18, Booth Street, Manchester	Aug. 7, 1862
383	HILL, WILLIAM, Hill Crest, Dordon, Tamworth	A.M. June 9, 1883 M. Aug. 3, 1889
384	HILTON, THOMAS WORTHINGTON, Wigan Coal and Iron Company, Limited, Wigan	Aug. 3, 1865
385	HINDMARSH, JOSEPH PARKER, Corrimal, South Coast, New South Wales, Australia	June 20, 1908
386	HINDSON, THOMAS, Framwellgate Colliery, near Durham	Dec. 9, 1905
387	HODGKIN, JONATHAN EDWARD, Shelleys, Darlington ...	Dec. 13, 1902
388	HODGSON, JACOB, Cornsay Colliery, Durham	June 8, 1895
389	HOGG, CHARLES EDWARD, 1, London Wall Buildings, London. E.C.	Oct. 12, 1895
390	HOGG, JOHN, Thornley Colliery Office, Thornley, S.O., County Durham	Dec. 12, 1903
391	HOLBERTON, WALTER TWINING, Compañía Estanífera de Llallagua, Llallagua, Bolivia, South America, *via* Buenos Aires i Tupiza	June 9, 1900
392	HOLLIDAY, MARTIN FORSTER, Langley Grove, Durham ...	May 1, 1875
393	HOLLIDAY, NORMAN STANLEY, Boyne Villa, Langley Moor, Durham	S. April 10, 1897 M. Feb. 13, 1904
394	HOMERSHAM, EDWIN COLLETT, The Randfontein Estates Gold-mining Company, Limited, P.O., Randfontein, Transvaal	Feb. 9, 1901
395	HOMERSHAM, THOMAS HENRY COLLETT, Vulcan Iron Works, Thornton Road, Bradford	Aug. 6, 1898
396	HOOD, GEORGE, 9, Agents Terrace, Boldon Colliery, S.O., County Durham	Dec. 14, 1907
397	HOOD, WILLIAM WALKER, Tredean, near Chepstow ...	April 9, 1904
398	HOOPER, EDWARD, Salisbury House, London Wall, London, E.C.	A.M. June 4, 1881 M. April 14, 1894

		Date of Election and of Transfer.
399	Hooper, James Augustus, Cannop, Coleford	Dec. 12, 1908
400	Hope, Edmund Louis, Abbottabad, N.W. Frontier, India	Oct. 9, 1897
401	Hopwood, Howell Arthur, Poste Restante, G.P.O., Singapore	Oct. 12, 1907
402	Hopwood, Isaac John, c/o Post Office, Dunolly, Victoria, Australia	Oct. 12, 1907
403	Hopwood, Kingsley, Beech Leigh, Buckley, Chester ...	June 20, 1908
404	Hopwood, William, Vron Haul, Buckley, Chester ...	Aug. 3, 1901
405	Horswill, Frederick Alva, Valley Springs, California, U.S.A.	Feb. 13, 1909
406	Horswill, Frederick J., 1070, Sixteenth Street, Oakland, California, U.S.A.	Oct. 14, 1899
407	Horwood-Barrett, Harold	June 8, 1907
408	Hosking, James, P.O. Box 1617, Johannesburg, Transvaal	June 21, 1894
409*	Hoskold, Carlos A. Lynes	June 8, 1895
410	Hoso, Shonosuke, Miike Colliery, Kyūshū, Japan	April 11, 1908
411	Hotchkis, Daniel, Mount Kembla Colliery, Wollongong, New South Wales, Australia	June 20, 1908
412	Howes, Frank T., Singareni Collieries, Deccan, India ...	A. Dec. 10, 1892 M. Oct. 14, 1893
413	Howson, Charles, Harraton Colliery, Chester-le-Street	S. Dec. 14, 1901 A. Aug. 4, 1906 M. June 8, 1907
414	Humble, Ernest, Lawson Street, Hamilton, Newcastle, New South Wales, Australia	S. Feb. 14, 1903 A. Aug. 3, 1907 M. April 11, 1908
415	Humble, John, West Pelton House, Beamish, S.O., County Durham	Feb. 8, 1902
416	Humble, William, Lawson Street, Hamilton, Newcastle, New South Wales, Australia	Oct. 14, 1893
417	Humphris, Henry, Blaenau Festiniog	Oct. 13, 1900
418	Hunter, Christopher, Cowpen Colliery Office, Blyth ...	A. Dec. 10, 1892 M. Dec. 12, 1903
419	Hunter, Robert, Gympie, Queensland, Australia	June 14, 1902
420	Hurst, George, Lauder Grange, Corbridge, S.O., Northumberland	S. April 14, 1883 M. Aug. 1, 1891
421	Hutchinson, John William, Llwyncelyn House, Porth, near Pontypridd	Oct. 14, 1899
422	Hutton, John George, Barfield, East Maitland, New South Wales, Australia	Dec. 10, 1904
423	Hylton, Frederick William, Ryhope Colliery, Sunderland	Aug. 3, 1907
424	Inskipp, Dudley James, c/o James Inskipp, 61, Rutland Gardens, Hove, Brighton	June 8, 1907
425	Jackson, Edmund, Tangier Buildings, Whitehaven ...	April 8, 1905
426	Jackson, Walter Geoffrey, Bramham Hall, Boston Spa, S.O., Yorkshire	June 7, 1873
427	Jacobs, Lionel Asher, Giridih, E.I.R., Bengal, India ..	S. Aug. 4, 1900 A. Aug. 4, 1906 M. April 13, 1907
428	James, William Henry Trewartha, Finsbury House, Blomfield Street, London, E.C.	Dec. 12, 1896
429	Jamieson, John William, Medomsley, S.O., County Durham	Aug. 2, 1902
430	Janitzky, Edward, Pymble, near Sydney, New South Wales, Australia	Aug. 6, 1904
431	Jarvie, James, Kembla Heights, near Wollongong, New South Wales, Australia	Feb. 8, 1908
432	Jefferson, Frederick, Whitburn Colliery, South Shields	Dec. 11, 1897
433	Jeffreys, James Henry, The Lisboa Mining and Development Company, Limited, 32, Great St. Helens, London, E.C.	Oct. 8, 1904

	Date of Election and of Transfer.
434 JENKINS, PHILIP THOMAS, Gwylfa, Llansamlet, S.O., Glamorgan	Dec. 10, 1904
435 JENKINS, WILLIAM, Ocean Collieries, Treorchy, Pontypridd	Dec. 6, 1862
436 JENNINGS, ALBERT, 12, Grainger Street, Darlington ...	June 20, 1908
437 JENNINGS, THOMAS BRYANT, P.O. Box 1565, Johannesburg, Transvaal	Dec. 10, 1904
438 JEPSON, HENRY, 39, North Bailey, Durham	S. July 2, 1872
	A.M. Aug. 2, 1879
	M. June 8, 1889
439*JOBLING, THOMAS EDGAR, Bebside, S.O., Northumberland (*Member of Council*)	S. Oct. 7, 1876
	A.M. Aug. 4, 1883
	M. June 8, 1889
440 JOHNS, BENNET, Station Road, Keswick	Dec. 9, 1905
441*JOHNS, JOHN HARRY (HENRY), P.O. Box 231, Johannesburg, Transvaal	June 21, 1894
442 JOHNSON, EDWARD	Dec. 9, 1905
443 JOHNSON, JAMES, Boldon Lodge, East Boldon, S.O., County Durham	A. Aug. 6, 1898
	M. Dec. 12, 1903
444 JOHNSTON, J. HOWARD, c/o Backus and Johnston, Lima, Peru, South America	Feb. 10, 1894
445 JOICEY, WILLIAM JAMES, Sunningdale Park, Berkshire ...	March 6, 1869
446 JONES, CLEMENT, Neath Colliery, Cessnock, New South Wales, Australia	Dec. 8, 1906
447 JONES, EVAN, Plas Cwmorthin, Blaenau Festiniog	April 13, 1907
448 JONES, JACOB CARLOS, Wollongong, New South Wales, Australia	Aug. 6, 1892
449 JONES, PERCY HOWARD, Ty Ceirios, Pontnewynydd, Pontypool	Oct. 11, 1902
450 JONES, ROBERT, 11, The Square, Blaenau Festiniog ...	April 3, 1909
451 JONES, THOMAS, 5, Little George Street, Westminster, London, S.W.	June 12, 1897
452 JORDAN, CECIL WILLIAM, Marlborough House, Marlborough Road, Roath, Cardiff	Dec. 14, 1907
453 JOYNES, JOHN JAMES, Ferndale, Lydbrook, Gloucestershire	Aug. 6, 1904
454 JUDD, HENRY ALEXANDER, 9, St. Mildred's Court, Poultry, London, E.C.	Oct. 8, 1898
455 KAYLL, ALFRED CHARLES, Gosforth, Newcastle-upon-Tyne	S. Oct. 7, 1876
	M. Aug. 3, 1889
456 KEARNEY, JOSEPH MUSGRAVE, Lismore, Whitehaven ...	Aug. 1, 1903
457 KEIGHLEY, FREDERICK CHARLES, Uniontown, Fayette County, Pennsylvania, U.S.A.	Aug. 4, 1900
458 KELLETT, MATTHEW HENRY, St. Helen's Colliery, Bishop Auckland	S. April 11, 1891
	M. Aug. 3, 1895
459 KERR, ANDREW, New Brancepeth Colliery, Durham ...	Dec. 14, 1907
460 KERR, DAVID GILLESPIE, Room 129-130, Confederation Life Building, Toronto, Canada	Aug. 4, 1900
461 KIDD, THOMAS, Jun., Linares, Provincia de Jaen, Spain ...	Aug. 3, 1895
462 KIRBY, MATTHEW ROBSON, c/o Addison Langhorne Steavenson, Holywell Hall, Durham	S. June 9, 1900
	A. Aug. 1, 1903
	M. Oct. 12, 1907
463 KIRKBY, WILLIAM, c/o Aire and Calder Navigation, Leeds	A.M. April 2, 1898
	M. Aug. 6, 1904
464 KIRKUP, AUSTIN, Manor House, Penshaw, Fence Houses	S. April 9, 1892
	M. June 12, 1897
465 KIRKUP, FREDERIC OCTAVIUS, Garesfield Colliery, Rowlands Gill, Newcastle-upon-Tyne	S. April 9, 1892
	A.M. April 25, 1896
	M. Feb. 14, 1903
466 KIRKUP, JOHN PHILIP, Burnhope, Durham (*Member of Council*)	April 11, 1891
467 KIRKUP, PHILIP, Leafield House, Birtley, S.O., County Durham	S. March 2, 1878
	A.M. Aug. 7, 1886
	M. Aug. 3, 1889
468 KIRSOPP, JOHN, Jun., Minera Anglo Hispana Company, Matallana, Province of Leon, North Spain	June 9, 1900

		Date of Election and of Transfer.
469	KIRTON, HUGH, Kimblesworth Colliery, Chester-le-Street ...	S. April 7, 1877
		A.M. Aug. 1, 1885
		M. June 8, 1889
470	KITCHIN, JAMES BATEMAN, Woodend House, Bigrigg, S.O., Cumberland	Aug. 5, 1905
471	KLEPETKO, FRANK, 307, Battery Park Building, 21-24, State Street, New York City, U.S.A.	Oct. 13, 1900
472*	KNOWLES, ROBERT, Ednaston Lodge, near Derby	April 10, 1886
473	KNOX, WILLIAM, Preston Colliery, North Shields	Oct. 13, 1906
474	KONDO, R., c/o Furukawa Mining Office, 1, Icchome Taesucho, Kojimachi, Tokyo, Japan	June 21, 1894
475	KORTE, CHRISTIAN, Standard Buildings, 38, Park Row, Leeds	Feb. 13, 1909
476*	KWANG, KWONG YUNG, Mines de Lincheng, Lin Teheng Sien, Lu-Han Railway, *via* Peking, North China ...	June 8, 1895
477	KYLE, GEORGE ROBERT, 6, Ravensworth Road, Dunston, Gateshead-upon-Tyne	Dec. 14, 1907
478	LAMB, ROBERT ORMSTON, Hayton, How Mill, Carlisle ...	Aug. 2, 1866
479	LANCASTER, JOHN, Overslade, near Rugby	March 2, 1865
480	LANCASTER, JOHN, Auchenheath, S.O., Lanarkshire	Sept. 7, 1878
481*	LANDERO, CARLOS F. DE, Apartado 3, Pachuca, Mexico ...	Feb. 15, 1896
482*	LAPORTE, HENRY, 35, rue de Turin, Brussels, Belgium ...	May 5, 1877
483	LATHBURY, GRAHAM CAMPBELL, East Indian Railway Collieries, Giridih, E.I.R., Bengal, India	Feb. 14, 1903
484	LATIMER, HUGH, St. Helen's Colliery, Bishop Auckland	S. Feb. 15, 1896
		A. Aug. 1, 1903
		M. Feb. 11, 1905
485	LAVERICK, JOHN WALES, 54, Manor House Road, Jesmond, Newcastle-upon-Tyne	A.M. Dec. 9, 1882
		M. Aug. 3, 1889
486	LAWN, JAMES GUNSON, University College, Johannesburg, Transvaal	July 14, 1896
487	LEACH, CHARLES CATTERALL, Seghill Colliery, Seghill, Dudley, S.O., Northumberland (*Member of Council*) ...	S. March 7, 1874
		A.M. Aug. 6, 1881
		M. Aug. 4, 1883
488	LEBOUR, GEORGE ALEXANDER LOUIS, Armstrong College, Newcastle-upon-Tyne, *Transactions*, etc., sent to Radcliffe House, Corbridge, S.O., Northumberland ...	Feb. 1, 1873
489	LECK, WILLIAM, H.M. Inspector of Mines, Cleator Moor, S.O., Cumberland	Nov. 24, 1894
490	LEE, JOHN WILSON RICHMOND, 70, St. Helen's Gardens, North Kensington, London, W.	Aug. 5, 1893
491	LEE, RICHARD HENRY LOVELOCK, The Pekin Syndicate's Mines, Honan, North China	Aug. 5, 1905
492	LEECH, ARTHUR HENRY, 11, King Street, Wigan	Feb. 9, 1901
493	LEWIS, SIR WILLIAM THOMAS, Bart., Mardy, Aberdare	Sept. 3, 1864
494	LIDDELL, HUGH, 2, May Street, Durham	Feb. 11, 1905
495	LIDDELL, JOHN MATTHEWS, Togston Hall, Acklington, S.O., Northumberland	S. March 6, 1875
		A.M. Aug. 6, 1881
		M. June 8, 1889
496	LIDSTER, RALPH, Langley Park Colliery, Durham	April 4, 1903
497	LISBOA, MIGUEL ARROJADO RIBEIRO, Rua Costa Gama, Villa Japurá, Petropolis, Rio de Janeiro, Brazil, South America	Aug. 5, 1905
498	LISHMAN, ROBERT RICHARDSON, Bretby Colliery, Burton-upon-Trent	S. June 9, 1883
		M. Aug. 1, 1891
499	LISHMAN, THOMAS, Hetton Colliery, Hetton-le-Hole, S.O., County Durham	S. Nov. 5, 1870
		M. Aug. 3, 1872
500	LISHMAN, TOM ALFRED, Harton Colliery, Tyne Dock, South Shields	S. Nov. 24, 1894
		A. Aug. 7, 1897
		M. April 13, 1901
501	LISHMAN, WILLIAM ERNEST, 4, Field House Terrace, Durham	June 10, 1893
502	LISLE, JAMES, Kroonstad Coal Estate Company, Limited, P.O. Box 118, Klerksdorp, Transvaal	S. July 2, 1872
		A.M. Aug. 3, 1878
		M. June 8, 1889

		Date of Election and of Transfer.
503	LIVEING, EDWARD H., Brookfield House, Long Stanton, Cambridge	S. Sept. 1, 1877 A.M. Aug. 2, 1884 M. Aug. 3, 1889
504	LLEWELLIN, DAVID MORGAN, Glanwern Offices, Pontypool	May 14, 1881
505	LOCKWOOD, ALFRED ANDREW, 46, Marmora Road, Honor Oak, London, S.E.	June 12, 1897
506	LONG, ERNEST, 2, Brookfield Terrace, Fairfield, Droylsden, Manchester	Aug. 4, 1906
507	LONGBOTHAM, GEORGE AUGUSTUS, Ings Foundry, Wakefield	Oct. 12, 1907
508	LONSDALE, TALBOT RICHARD, Malton Colliery, near Durham	June 14, 1902
509*	LOUIS, DAVID ALEXANDER, Savage Club, 6 and 7, Adelphi Terrace, London, W.C.	April 8, 1893
510	LOUIS, HENRY, 4, Osborne Terrace, Newcastle-upon-Tyne (*Member of Council*)	Feb. 15, 1896
511	LOWDON, THOMAS, Hamsteels, near Durham	Dec. 14, 1889
512	LUPTON, ARNOLD, 7, Victoria Street, Westminster, London, S.W.	Nov. 6, 1869
513	LYALL, EDWARD, Barton, S.O., Yorkshire	Oct. 14, 1905
514	LYALL, WILLIAM, 4, Vane Terrace, Darlington	Feb. 13, 1909
515	MACARTHUR, JAMES DUNCAN, Bangkok, Siam	Oct. 13, 1906
516	MACARTHUR, JOHN STEWART, 74, York Street, Glasgow ...	April 8, 1893
517	MCCANN, JAMES JOSEPH HUNTER, American Exchange, 60, Haymarket, London, S.W.	Dec. 12, 1908
518	MCCARTHY, EDWARD THOMAS, 125, Victoria Street, London, S.W.	A.M. Oct. 8, 1887 M. Aug. 3, 1889
519	MCCREATH, JAMES, 208, St. Vincent Street, Glasgow ...	March 5, 1870
520	MCDOWELL, BENJAMIN FRANCIS, c/o Percy Tarbutt and Company, P.O. Box 669, Bulawayo, Rhodesia, South Africa	Dec. 12, 1903
521	MACFARLANE, RIENZI WALTON, c/o Parral Foreign Club, Parral, Estado Chihuahua, Mexico, *via* New York ...	April 9, 1904
522	MCGEACHIE, DUNCAN, West Wallsend, New South Wales, Australia	Nov. 24, 1894
523	MCINERNY, AUGUSTIN JOSEPH, 16, rue d'Autriche, Tunis ...	Aug. 4, 1906
524	MCINTOSH, ROBERT, Assistant Inspector of Mines, Dunedin, New Zealand	April 9, 1904
525	MACKINTOSH, JAMES, Burrea Coal Company, Salanpur Colliery, Sitarampur, E.I.R., Bengal, India	Oct. 12, 1895
526	MCLELLAN, NEIL, Idsley House, Spennymoor	Dec. 13, 1902
527	MCMURTRIE, GEORGE EDWIN JAMES, Radstock, Bath ...	S. Aug. 2, 1884 M. Dec. 12, 1891
528	MCMURTRIE, JAMES, 5, Belvedere Road, Durdham Park, Bristol	Nov. 7, 1863
529	MCNEILL, BEDFORD, 1, London Wall Buildings, London, E.C.	Dec. 11, 1897
530	MADDISON, W. H. F., The Lindens, Darlington	June 14, 1890
531	MAMMATT, JOHN ERNEST, 1, Albion Place, Leeds	Aug. 3, 1865
532	MANNING, ARTHUR HOPE, P.O. Box 88, Heidelberg, Transvaal	Dec. 11, 1897
533*	MARKHAM, GERVASE EDWARD, Gloucester Villa, Darlington	S. Dec. 4, 1875 A.M. Aug. 7, 1880 M. June 8, 1889
534	MARKS, HERBERT T., c/o Royal Colonial Institute, Northumberland Avenue, London, W.C.	Oct. 12, 1901
535	MARLEY, FREDERIC THOMAS, Monkscroft, St. Bees, S.O., Cumberland	S. Oct. 8, 1898 A. Aug. 5, 1905 M. Dec. 14, 1907
536	MARR, JAMES HEPPELL, Castlecomer, S.O., County Kilkenny	A. Feb. 13, 1897 M. Dec. 12, 1903
537*	MARRIOTT, HUGH FREDERICK, c/o Wernher, Beit and Company, 1, London Wall Buildings, London, E.C. ...	Dec. 12, 1896
538	MARSH, THOMAS ASPINALL, Leaders Buildings, Wigan ...	Oct. 10, 1908
539	MARTIN, HENRY STUART, c/o H. Eckstein and Company, Johannesburg, Transvaal	April 13, 1907

		Date of Election and of Transfer.
540	MARTIN, HENRY WILLIAM, Sherwood, Newport Road, Cardiff	Oct. 9, 1897
541	MARTIN, TOM PATTINSON, 22, Station Road, Workington ...	April 4, 1903
542	MATHIESON, ALEXANDER, Hetton Colliery, Carrington, near Newcastle, New South Wales, Australia...	Nov. 5, 1892
543	MATTHEWS, FREDERICK BERKLEY, Lartington Hall, Darlington...	A.M. Dec. 9, 1882 M. June 8, 1889
544	MATTHEWS, JOHN, c/o R. and W. Hawthorn, Newcastle-upon-Tyne	A.M. April 11, 1885 M. Aug. 3, 1889
545	MAURICE, WILLIAM, Hucknall Torkard, Nottingham ...	Dec. 14, 1907
546	MAWSON, ROBERT BRYHAM, Elm Bank, Wigan	June 11. 1892
547	MAY, GEORGE, Clervaux Castle, Croft, Darlington (PAST-PRESIDENT, *Member of Council*)	March 6, 1862
548	MEIN, HENRY JOHNSON, Carterthorne Colliery, Toft Hill, Bishop Auckland	Dec. 9, 1899
549	MELLON, HENRY, Brook Lea, Askam, S.O., Lancashire ...	April 25, 1896
550	MENZIES, JOSEPH FREDERICK, Roslyn, Washington, U.S.A.	June 10, 1905
551	MERIVALE, CHARLES HERMAN, Middleton Estate and Colliery Company, Middleton, Leeds	S. June 9, 1900 A. Aug. 6, 1904 M. Dec. 14, 1907
552	MERIVALE, JOHN HERMAN, Togston Hall, Acklington, S.O., Northumberland (HONORARY SECRETARY, PAST-PRESIDENT, *Member of Council*)	May 5, 1877
553	MERZ, CHARLES HESTERMAN, Collingwood Buildings, Collingwood Street, Newcastle-upon-Tyne	June 10, 1903
554	METCALF, ALFRED T., United Reefs (Sheba), Limited, Eureka City, De Kaap, South Africa	June 21, 1894
555	MICHELL, THOMAS HENRY, Pool Mining Company, Bettws-y-coed, S.O., Carnarvonshire	April 3, 1909
556	MIDDLETON, ROBERT, Sheep Scar Foundry, Leeds	Aug. 1, 1891
557	MILLER, JOHN HENRY, South Hetton, S.O., County Durham	A. Dec. 8, 1894 M. April 4, 1903
558	MILLER, J. P. K., H. C. Frick Coke Company, Scottdale, Pennsylvania, U.S.A.	Dec. 14, 1895
559	MITCHINSON, ROBERT, Catchgate House, Annfield Plain, S.O., County Durham	Feb. 4, 1865
560	MOLENGRAAFF, GUSTAAF ADOLF FREDERIK, 43, van Stolberglaan, The Hague	Oct. 14, 1899
561	MONTGOMERY, ALEXANDER, State Mining Engineer, Department of Mines, Perth, Western Australia	Dec. 9, 1899
562	MOORE, MARSHALL GREENE, Moorland, Johnstown, Pennsylvania, U.S.A.	Feb. 11, 1905
563	MOORE, ROBERT THOMAS, 142, St. Vincent Street, Glasgow...	Oct. 8, 1892
564	MOORE, RICHARD WALKER, Somerset House, Whitehaven	S. Nov. 5, 1870 M. Aug. 4, 1877
565	MOORE, WILLIAM, Westfield, Loftus, S.O., Yorkshire ...	A.M. Nov. 19, 1881 M. Aug. 3, 1889
566	MOREING, CHARLES ALGERNON, 20, Copthall Avenue, London, E.C.	Nov. 7, 1874
567	MORGAN, JOHN, Stanley Villa, Crook, S.O., County Durham	Dec. 9, 1905
568	MORISON, JOHN, 14, Saville Row, Newcastle-upon-Tyne	A.M. Dec. 4, 1880 M. Aug. 3, 1889
569	MORLAND-JOHNSON, EDWARD THOMAS, Bank of England Chambers, Tib Lane, Cross Street, Manchester ...	April 10, 1897
570	MORRIS, JOHN, Lydbrook Colliery, Lydbrook, Gloucestershire	A. April 4, 1903 M. Aug. 6, 1904
571	MORRIS, WILLIAM, Waldridge Colliery, Chester-le-Street ...	Oct. 8. 1892
572	MORRISON, EDWARD, 51, Pica Cottages, Distington, S.O., Cumberland	June 20, 1908
573	MORSE, WILLARD S., Seaford, Delaware, U.S.A.	June 13, 1896
574*	MORT, ARTHUR, Khost, N. W. R., Baluchistan, India ...	Dec. 9, 1899
575	MORTON, REGINALD CHARLES, 31, Broomhall Place, Sheffield	Aug. 3, 1907
576	MOUNT-HAES, ANDREW, 3, Bellasis Avenue, Streatham Hill, London, S.W.	Dec. 10, 1904

		Date of Election and of Transfer.
577	MOUNTAIN, WILLIAM CHARLES, The Hermitage, Gateshead-upon-Tyne (*Member of Council*)	April 9, 1892
578	MUNDLE, ARTHUR, Murton Chambers, 8, Grainger Street, Newcastle-upon-Tyne	S. June 5, 1875 M. Aug. 4, 1877
579	MUNDLE, HARRY ARTHUR, High Marley Hill, Swalwell, S.O., County Durham	June 14, 1902
580	MURRAY, WILLIAM CUTHBERT, Littletown, Durham ...	June 10, 1903
581	NAGAZUMI, JUNJIRO, c/o Takata and Company, 88, Bishopsgate Street Within, London, E.C.	Dec. 12, 1908
582	NESBIT, JOHN STRAKER, Marley Hill Colliery, Swalwell, S.O., County Durham	S. Oct. 9, 1897 A. Aug. 5, 1905 M. Oct. 12, 1907
583	NESS, WILLIAM WATERS VAN, 622-623, Salisbury House, London Wall, London, E.C.	A.M. Aug. 7, 1897 M. Dec. 11, 1897
584	NETTLE, HENRY, Tremayne House, Basset Terrace, Camborne	Dec. 12, 1908
585	NEVIN, JOHN, Littlemoor House, Mirfield, S.O., Yorkshire	S. May 2, 1868 M. Aug. 5, 1871
586	NEWBERY, FREDERICK, 230, Camden Road, London, N.W.	A.M. April 2, 1898 M. Feb. 13, 1904
587	NEWBIGIN, HENRY THORNTON, 3, St. Nicholas' Buildings, Newcastle-upon-Tyne	Oct. 13, 1894
588	NICHOLSON, ARTHUR DARLING, H.M. Inspector of Mines, 2, Graingerville, Newcastle-upon-Tyne (*Member of Council*)...	S. June 13, 1885 A. Aug. 4, 1894 M. Feb. 12, 1898
589	NICHOLSON, JOHN HODGSON, Cowpen Colliery Office, Blyth (*Member of Council*)	S. Oct. 1. 1881 A. Aug. 3, 1889 M. April 8, 1893
590	NICHOLSON, MARSHALL, Middleton Colliery, Leeds	Nov. 7, 1863
591	NIERSES, J. W., Budroochuck Colliery, Sijua P.O., E. I. Railway, Bengal, India	Dec. 10, 1904
592	NISBET, NORMAN, Houghton Colliery Office, Houghton-le-Spring, S.O., County Durham	S. Nov. 24, 1894 A. Aug. 3, 1901 M. Aug. 6, 1904
593	NOBLE, THOMAS GEORGE, Sacriston Colliery, Durham ...	A. Feb. 13, 1892 M. June 8, 1895
594	NOGARA, BERNARDINO, Galata, Constantinople, Turkey ...	Dec. 14, 1907
595	NÓMI, AITARÓ, Hójó Colliery, Province of Buzen, Japan	Aug. 5, 1899
596	NORRIS, ROBERT VAN ARSDALE, Wilkes-Barré, Pennsylvania, U.S.A.	Feb. 13, 1909
597	NORTHEY, ARTHUR ERNEST, The Elms, North Parade, Aberystwyth	June 10, 1903
598	OATES, ROBERT JOSEPH WILLIAM, Rewah State Collieries, Umaria, C. India, Bengal Nagpur Railway	S. Feb. 10, 1883 A.M. Aug. 1, 1891 M. Dec. 12, 1891
599	O'DONAHUE, THOMAS ALOYSIUS, 72, Swinley Road, Wigan	A.M. Dec. 14, 1895 M. Oct. 9, 1897
600	OLDHAM, GEORGE, 25, Western Hill, Durham	Nov. 5. 1892
601	OLSEN, ARNOLD CARL LOUIS, P.O. Box 1056, Johannesburg, Transvaal	Dec. 9, 1905
602	ORNSBY, EDWARD THOMAS, Benwell Colliery, Newcastle-upon-Tyne	Dec. 8, 1900
603	ORNSBY, ROBERT EMBLETON, Seaton Delaval Colliery, Northumberland	June 11, 1898
604	OSBORNE, FRANCIS DOUGLAS, Gopeng, Perak, Federated Malay States	Feb. 14, 1903
605*	OSHIMA, ROKURO, No. 121, Yoyogi, Toyotama-gun, Tokyo, Japan	April 10, 1897
606	OUGHTON, WILLIAM, Milburn House, Newcastle-upon-Tyne	Feb. 8, 1908
607	OWENS, WILLIAM DAVID, Lehigh Valley Coal Company, 239, Philadelphia Avenue, Pittston, Pennsylvania, U.S.A.	Feb. 11, 1905

		Date of Election and of Transfer.	
608	PAGE, ARTHUR HERBERT SHEEPSHANKS, Escomb, Bishop Auckland	Aug.	3, 1907
609	PALEY, GEORGE, Glebe House, Whitburn, Sunderland	Oct.	12, 1901
610	PALMER, CLAUDE BOWES, Wardley Hall, Pelaw, Newcastle-upon-Tyne	A.M. Nov.	5, 1892
		M. June	8, 1895
611	PALMER, HENRY, Medomsley, S.O., County Durham (VICE-PRESIDENT, *Member of Council*)	S. Nov.	2, 1878
		A.M. Aug.	4, 1883
		M. Aug.	3, 1889
612	PAMELY, CALEB, 64, Cromwell Road, Bristol	S. Sept.	5, 1868
		M. Aug.	5, 1877
613	PAMPLIN, ELIAH GEORGE, Cherry Hinton, Cambridge	Aug.	1, 1903
614	PARISH, CHARLES EDWARD, 31, Hanger Lane, Ealing, London, W.	Feb.	10, 1900
615	PARRINGTON, MATTHEW WILLIAM, Wearmouth Colliery, Sunderland (VICE-PRESIDENT, *Member of Council*)	S. Dec.	1, 1864
		M. Aug.	6, 1870
616	PARRINGTON, THOMAS ELLIOT, Carley Hill, Monkwearmouth, Sunderland	S. Aug.	3, 1895
		A. Aug.	1, 1903
		M. Oct.	12, 1907
617	PARSONS, HON. CHARLES ALGERNON, Heaton Works, Newcastle-upon-Tyne	A.M. June	12, 1886
		M. Aug.	3, 1889
618	PASCOE, THOMAS, Australasian Club, St. Mary Axe, London, E.C.	A.M. April	10, 1897
		M. June	12, 1897
619	PATERSON, ANDREW JAMES, c/o Town Hall, Wellington, New Zealand	June	11, 1898
620	PAYNE, FRANCIS WILLIAM, Government Insurance Building, Dunedin, New Zealand	Feb.	11, 1905
621	PEAKE, R. CECIL, Cumberland House, Redbourn, St. Albans	S. Feb.	7, 1880
		A.M. Aug.	7, 1886
		M. Aug.	3, 1889
622	PEARSE, JOHN WALTER, Grivynée-lez-Liége, Belgium	June	10, 1899
623	PEARSON, CLEMENT ALFRED RITSON, South End Avenue, Darlington	June	11, 1904
624	PEDELTY, SIMON, Broomhill Colliery, Acklington, S.O., Northumberland	A. Dec.	10, 1892
		M. Dec.	14, 1907
625	PEEL, ROBERT, New Brancepeth Colliery, Durham	Aug.	6, 1892
626	PERCY, FRANK, Mining College, Wigan. *Transactions* sent to The Librarian, Wigan Free Library, Wigan	Dec.	12, 1903
627	PERCY, ROBERT MCLEOD, Karagandy Colliery, Spassky Copper-mines, Limited, Spassky Zabod, Akmolinsk, Siberia	Dec.	14, 1907
628	PHILLIPS, PERCY CLEMENT CAMPBELL, Wallsend Colliery, near Newcastle-upon-Tyne	June	10, 1903
629	PINGSTONE, GEORGE ARTHUR, P.O. Box 445, Bulawayo, Rhodesia, South Africa	A.M. June	11, 1898
		M. Dec.	10, 1898
630	PLUMMER, JOHN, Bishop Auckland	June	8, 1889
631	POLLITZER, SAMUEL JOSEPH, Terrys Chambers, 14, Castlereagh Street, Sydney, New South Wales, Australia	April	12, 1902
632	POOLE, WILLIAM, School of Mines, Charters Towers, Queensland, Australia	Feb.	13, 1909
633*	POORE, GEORGE BENTLEY, 1730, Cupouse Avenue, Scranton, Pennsylvania, U.S.A.	A.M. Dec.	10, 1898
		M. April	8, 1899
634	PORTER, JOHN BONSALL, McGill University, Montreal, Quebec, Canada	Dec.	8, 1900
635	POTTER, ERNEST HENRY, Tilmanstone Sinking, Eythorne, Dover	Feb.	8, 1908
636	POWELL, CHARLES HENRY, International Mines, Limited, Biggenden, *via* Maryborough, Queensland, Australia	June	14, 1902
637	PREST, JOHN JOSEPH, Hardwick Hall, Castle Eden, S.O., County Durham	Feb.	9, 1901
638	PRICE, FRANCIS HOLBORROW GLYNN, Longlands Place, Swansea	June	10, 1899
639	PRICE, STEPHEN RICHARD, Dilston House, Corbridge, S.O., Northumberland	S. Nov.	3, 1877
		A.M. Aug.	1, 1885
		M. Aug.	3, 1889

		Date of Election and of Transfer.
640	PRICE, SAMUEL WARREN, The Wern, Peterston-super-Ely, Cardiff...	Aug. 3, 1895
641	PRICE, WILLIAM FREDERICK, A Floor, Milburn House, Dean Street, Newcastle-upon-Tyne	June 20, 1908
642	PRINGLE, JOHN ARCHIBALD, c/o J. C. Reddie, 4, Earl's Court Square, London, S.W.	Dec. 10, 1898
643	PRINGLE, ROBERT WILLIAM, Norfolk House, Laurence Pountney Hill, London, E.C.	Aug. 1, 1903
644*	PRIOR, HON. EDWARD GAWLER, Victoria, British Columbia. *Transactions* sent to Thomas R. Stockett, Western Fuel Company, Nanaimo, British Columbia	Feb. 7, 1880
645	PULLON, JOSEPH THOMAS, Rowangarth, North Park Road, Roundhay, Leeds	Feb. 11, 1905
646	PURDY, RICHARD, Katrasgarh P.O., E.I.R., Bengal, India...	Aug. 1, 1908
647	RAE, JOHN LIVINGTON CAMPBELL, 40, Church Street, Newcastle, New South Wales, Australia	Oct. 14, 1899
648	RAINE, FREDERICK JAMES, Etherley Grange 'Colliery, Bishop Auckland	S. Feb. 15, 1896 A. Aug. 6, 1904 M. Feb. 9, 1907
649	RAMSAY, JOHN, Tursdale Colliery, Ferry Hill	A. April 27, 1895 M. Feb. 13, 1904
650	RAMSAY, WILLIAM HENRY, South Tanfield Colliery, Stanley, S.O., County Durham	June 8, 1907
651	RANDOLPH, BEVERLEY S., Barkeley Springs, West Virginia, U.S.A.	Aug. 4, 1894
652	RANKIN, THOMAS THOMSON, Mining and Technical College, Wigan	April 9, 1904
653	RATEAU, AUGUSTE, 7, rue Bayard, Paris, France	Aug. 2, 1902
654	RAY, CHARLES EDMUND, Whinfield, near Ulverston ...	Aug. 3, 1907
655	REDMAN, SYDNEY GEORGE, 15, Osborne Terrace, Gosforth, Newcastle-upon-Tyne	Feb. 10, 1906
656	REDWOOD, SIR BOVERTON, Wadham Lodge, Wadham Gardens, London, N.W.	June 21, 1894
657*	REES, ITHEL TREHARNE, Guildhall Chambers, Cardiff ...	April 4, 1903
658	REES, ROBERT THOMAS, Glandare, Aberdare	Aug. 7, 1897
659	REES, WILLIAM THOMAS, Maesyffynon, Aberdare ...	A.M. Oct. 9, 1897 M. Feb. 12, 1898
660	RENWICK, THOMAS CHARLTON, Lumley Thicks, Fence Houses	April 14, 1894
661	RHODES, CHARLES EDWARD, Lane End House, Rotherham	Aug. 4, 1883
662	RHODES, FRANCIS BELL FORSYTH, United States Zinc Company, Pueblo, Colorado, U.S.A.	Feb. 10, 1894
663	RICH, FRANCIS ARTHUR, Vincent Road, Remnera, Auckland, New Zealand	Aug. 5, 1899
664	RICHARDS, FRED, Blaenau, Compton Road, Canonbury, London, N.	Aug. 3, 1907
665	RICHARDS, THOMAS J., 53, Strand, Ferndale, Pontypridd	Oct. 10, 1896
666	RICHARDSON, HENRY, Eden Mount, Wetheral, Carlisle ...	March 2, 1865
667	RICHARDSON, NICHOLAS, c/o Mrs. James Richardson, South Ashfield, Newcastle-upon-Tyne	S. Dec. 12, 1896 A. Aug. 3, 1901 M. Dec. 14, 1901
668	RICHARDSON, ROBERT, Summerhill House, Blaydon-upon-Tyne, S.O., County Durham	A. Feb. 8, 1890 M. Aug. 3, 1895
669	RIDGE, HARRY MACKENZIE, Owton Manor, Seaton Carew, West Hartlepool	Dec. 14, 1907
670	RIDLEY, NORMAN BACKHOUSE, 2, Collingwood Street, Newcastle-upon-Tyne	June 8, 1895
671	RIGBY, THOMAS HENRY, Leaders Buildings, King Street, Wigan	Dec. 12, 1908
672	RITSON, JOHN RIDLEY, Burnhope Colliery, Lanchester, Durham	S. April 11, 1891 A.M. Aug. 3, 1895 M. Feb. 14, 1903
673	RITSON, UTRICK ALEXANDER, Milburn House, Newcastle-upon-Tyne	Oct. 7, 1871

Date of Election and of Transfer.

674 ROBBINS, PERCY ARTHUR, McKinley-Darragh Mine, Cobalt, Ontario, Canada ... ... Oct. 12, 1901

675 ROBERTS, JAMES, Jun., Perran House, Perranporth, S.O., Cornwall ... ... Dec. 14, 1895

676 ROBERTS, JOHN, Laxey, S.O., Isle of Man ... ... Dec. 9, 1905

677 ROBERTS, STEPHEN, Luipaards Vlei Estate and Gold-mining Company, P.O. Box 53, Krugersdorp, Transvaal ... April 28, 1900

678 ROBERTS, WILLIAM, Bella Vista, Perranporth, S.O., Cornwall ... ... Aug. 4, 1906

679 ROBERTSON, ANDREW, 49, Mining Exchange, Ballarat, Victoria, Australia ... ... Aug. 7, 1897

680 ROBERTSON, DANIEL ALEXANDER WILBERFORCE, Metropolitan Colliery, Helensburgh, near Sydney, New South Wales, Australia ... ... Aug. 6, 1892

681*ROBERTSON, JAMES ROBERT MILLAR, 40, Pitt Street, Sydney, New South Wales, Australia ... ... Aug. 2, 1890

682*ROBINS, SAMUEL MATTHEW, 28, Harefield Road, Brockley, London, S.E. *Transactions* sent to Thomas R. Stockett, Western Fuel Company, Nanaimo, British Columbia ... ... Oct. 12, 1895

683 ROBINSON, FRANCIS JAMES, Wycliffe, South Parade, Whitley Bay, S.O., Northumberland ... ... Oct. 13, 1906

684 ROBINSON, GEORGE, Boldon Colliery, S.O., County Durham June 10, 1899

685 ROBINSON, G. C., Brereton and Hayes Colliery, Rugeley ... Nov. 5, 1870

686 ROBINSON, GEORGE HENRY, Jun., Esplanade, Sunderland ... S. Dec. 9, 1899
M. April 8, 1905

687 ROBINSON, JOHN, High Hedgefield, Blaydon-upon-Tyne, S.O., County Durham ... ... Feb. 10, 1900

688 ROBINSON, J. B., Colliery Offices, Tow Law, S.O., County Durham ... ... Aug. 5, 1893

689 ROBINSON, JOHN THOMAS, South Medomsley Colliery, Dipton, S.O., County Durham ... ... Feb. 13, 1892

690 ROBINSON, ROBERT DOBSON, Tamworth Colliery Company, Tamworth ... ... Feb. 9, 1901

691 ROBINSON, TIMOTHY, Ryhope Colliery, Sunderland ... ... Feb. 8, 1902

692 ROBSON, J. S., Butterknowle Colliery, Butterknowle, S.O., County Durham ... ... May 15, 1862

693 ROCHESTER, WILLIAM, Highfield, Beechwood Avenue, Ryton, S.O., County Durham ... ... A. Dec. 10, 1898
M. Dec. 12, 1908

694 RODEWALD, RUDOLF, Nenthead Mines, Nenthead, Alston, S.O., Cumberland ... ... April 7, 1906

695 ROELOFSEN, JEAN ADOLF, Post Office Buildings, Middlesbrough ... ... Aug. 3, 1907

696 RONALDSON, JAMES HENRY, P.O. Box 1763, Johannesburg, Transvaal ... ... Aug. 6, 1892

697 ROSS, HUGH, Dean and Chapter Colliery, Ferry Hill ... Aug. 6, 1892

698 ROUTLEDGE, WILLIAM HENRY, Woodfield Park, Blackwood, Newport, Monmouthshire ... ... S. Oct. 7, 1876
A.M. Aug. 1, 1885
M. June 8, 1889

699 ROWE, JOSEPH SEYMOUR, Metropolitan Colliery, Helensburgh, New South Wales, Australia ... ... Aug. 3, 1907

700 ROWLEY, WALTER, 20, Park Row, Leeds ... ... Aug. 5, 1893

701 RUMBOLD, WILLIAM RICHARD, Oruro, Bolivia, South America, *via* Buenos Aires i Tupiza ... ... June 14, 1902

702 RUSSELL, ROBERT, Coltness Iron Works, Newmains, S.O., Lanarkshire ... ... Aug. 3, 1878

703 RUTHERFORD, ROBERT, Mainsforth, Ferry Hill ... ... Oct. 11, 1902

704 RUTHERFORD, WILLIAM, Lindum House, Gateshead-upon-Tyne ... ... Oct. 3, 1874

705 RUTHERFORD, WILLIAM, Jun., South Derwent Colliery, Annfield Plain, S.O., County Durham ... ... Feb. 9, 1901

706 RYAN, WILLIAM ARTHUR, Lonely Gold-mining Company, Lonely Mine, Private Bag, P.O., Bulawayo, Rhodesia, South Africa ... ... Dec. 12, 1908

		Date of Election and of Transfer.
707*	Saise, Walter, Stapleton, Bristol	A.M. Nov. 3, 1877 M. Aug. 3, 1889
708	Sam, Thomas Birch Freeman, c/o F. and A. Swanzy, Cape Coast Castle, West Africa	Aug. 5, 1893
709	Samborne, John Stukely Palmer, Timsbury House, Bath	Aug. 1, 1891
710	Sample, James Bertram, Bunker Hill, Fence Houses ...	S. Jan. 19, 1895 A. Aug. 4, 1900 M. Oct. 10, 1903
711*	Samwell, Nicholas, c/o Alexander Forbes, 71, Phayre Street, Rangoon, Burma, India	April 13, 1901
712	Sandow, William John Josiah, 1a, Telferscot Road, Streatham Hill, London, S.W.	Feb. 8, 1908
713	Saunders, David William Alban, Worcester Chambers, Swansea	A.M. Feb. 12, 1898 M. June 11, 1898
714	Saunders, William Thomas, Ivydene, West Cross, S.O., Glamorgan	June 12, 1897
715*	Sawyer, Arthur Robert, 824, Salisbury House, London Wall, London, E.C.	S. Dec. 6, 1873 A.M. Aug. 2, 1879 M. June 8, 1889
716	Schmidt, Henry Morton, United Coal Company, 804, Bank for Savings Building, Pittsburgh, Pennsylvania, U.S.A.	Aug. 1, 1908
717	Schnabel, Leberecht Ferdinand Richard, Sun Buildings, Corner of Bourke and Queen Streets, Melbourne, Victoria, Australia	April 13, 1907
718	Schwarz, Paul, Dortmund, Crook, S.O., County Durham	April 9, 1904
719	Scorer, John, c/o J. Crawford and Sons, Limited, Bonnersfield Engine Works, Sunderland	Dec. 12, 1903
720	Scott, Anthony, Netherton Colliery, Nedderton, Newcastle-upon-Tyne	April 8, 1905
721	Scott, Charles F., Newbell, Consett, S.O., County Durham	S. April 11, 1874 M. Aug. 4, 1877
722	Scott, Ernest, Sun Buildings, Newcastle-upon-Tyne ...	April 9, 1892
723	Scott, Edward Charlton, Woodside Cottage, Totley Rise, Sheffield	A. Oct. 8, 1892 M. Feb. 11, 1899
724	Scott, George Henry Hall, c/o Thomas Emerson Forster, 3, Eldon Square, Newcastle-upon-Tyne	S. April 12, 1902 M. Dec. 8, 1906
725	Scott, Herbert Kilburn, 46, Queen Victoria Street, London, E.C.	Oct. 11, 1902
726	Scoular, George, St. Bees, S.O., Cumberland	July 2, 1872
727	Selby, John Baseley, Leigh	April 25, 1896
728	Severs, Joseph, North Walbottle, Newburn, S.O., Northumberland	June 8, 1901
729	Severs, William, Beamish, S.O., County Durham... ...	A. Nov. 5, 1892 M. Dec. 8, 1900
730	Shanks, John, Coal Creek, Fernie, British Columbia ...	Aug. 5, 1905
731	Sharp, Jacob, Lambton House, Fence Houses	Dec. 14, 1901
732	Sharp, Robert Rich	April 3, 1909
733*	Shaw, James, 41, Wicksteed Street, Wanganui, New Zealand	Dec. 12, 1896
734	Sheafer, Arthur Whitcomb, Pottsville, Pennsylvania, U.S.A.	Aug. 4, 1894
735	Shiel, John, South Garesfield Colliery, Rowlands Gill, Newcastle-upon-Tyne	May 6, 1871
736	Simon, Frank, Rand Club, Johannesburg, Transvaal ...	Dec. 14, 1895
737	Simpson, Charles Liddell, Engine Works, Grosvenor Road, Pimlico, London	April 8, 1893
738	Simpson, Francis L. G., Mohpani Coal-mines, Gadawarra, C.P., India	A.M. Dec. 13, 1884 M. Aug. 3, 1889
739	Simpson, Frank Robert, Hedgefield House, Blaydon-upon-Tyne, S.O., County Durham (*Member of Council*) ...	S. Aug. 4, 1883 M. Aug. 1, 1891
740	Simpson, John, Heworth Colliery, Felling, S.O., County Durham (Vice-President, *Member of Council*)	S. Dec. 6, 1866 M. Aug. 1, 1868

	Date of Election and of Transfer.
741 Simpson, John Bell, Bradley Hall, Wylam, S.O., Northumberland (Past-President, *Member of Council*) ...	Oct. 4, 1860
742 Simpson, Robert Rowell, Inspector of Mines, Asansol, E.I.R., Bengal, India	S. Aug. 3, 1895 A. Aug. 2, 1902 M. Oct. 11, 1902
743 Simpson, Thomas Ventress, Throckley Colliery, Newburn, S.O., Northumberland	S. Dec. 14, 1895 A. Aug. 2, 1902 M. Dec. 13, 1902
744 Skertchley, Sydney A. R.	April 13. 1901
745 Slinn, Thomas, 40, Park Avenue, Whitley Bay, S.O., Northumberland	July 2, 1872
746 Smallwood, Percy Edmund, Garesfield Colliery, High Spen, Newcastle-upon-Tyne	A. Oct. 11, 1902 M Oct. 12, 1907
747 Smart, Alexander, c/o Frazer and Chalmers, Limited, Erith, S.O., Kent	Feb. 10, 1894
748*Smith, Richard Clifford, Ashford Hall, Bakewell ...	Dec. 5, 1874
749 Smith, Robert Fleming, Hunters Villa, Parkside, Cleator Moor, S.O., Cumberland	Aug. 6, 1904
750 Smith, William, P.O. Box 653, Johannesburg, Transvaal ...	Oct. 11, 1902
751 Smith, William Woodend, Crossgill House, Frizington, S.O., Cumberland	Aug. 6, 1904
752 Sopwith, Arthur, Wavertree, Handsworth, Staffordshire	Aug. 6, 1863
753 Southern, Edmund Octavius, North Seaton Hall, Morpeth	S. Dec. 5, 1874 A.M. Aug. 1, 1885 M. June 8, 1889
754 Southern, John, Heworth Colliery, Felling, S.O., County Durham	A. Dec. 14, 1889 M. April 8, 1899
755 Southern, R. W. A., 33, The Parade, Cardiff	Aug. 3, 1865
756 Southwood, Reginald Thomas Enfield, Nether House, Spencer Road, Putney, London, S.W.	Feb. 10, 1906
757 Spence, Robert Foster, Backworth, Newcastle-upon-Tyne	S. Nov. 2, 1878 A.M. Aug. 2, 1884 M. Aug. 4, 1889
758 Spencer, Francis H.	Dec. 13, 1890
759 Stainton, William, Euston Hotel, London	Feb. 13, 1909
760 Stanley, George Hardy, Technical Institute, Johannesburg, Transvaal	April 12, 1902
761 Steavenson, Addison Langhorne, Durham (Past-President, *Member of Council*)	Dec. 6, 1855
762 Steavenson, Charles Herbert, Redheugh Colliery, Gateshead-upon-Tyne	S. April 14, 1883 A. Aug. 1, 1891 M. Aug. 3, 1895
763 Steel, Robert, Woodhouse, Whitehaven	Aug. 5, 1905
764 Stephens, Francis Joseph, Blackwell's Development Corporation, Limited, Knaben Grube, Fjotland, *via* Flekkefjord, Norway	Oct. 12, 1907
765 Stephenson, Ralph, Pemberton Collieries, Wigan ...	Dec. 10, 1904
766 Stevens, Arthur James, Uskside Iron Works, Newport, Monmouthshire	April 8, 1893
767 Stevens, James, 9, Fenchurch Avenue, London, E.C. ...	Feb. 14, 1885
768 Stevinson, Peter B., Dunholm, Lesbury Road, Heaton, Newcastle-upon-Tyne	April 9, 1904
769 Stewart, William, Foxwood, Kent Road, Harrogate ...	S. Oct. 8, 1898 M. April 9, 1904
770 Stewart, William, Tillery Collieries, Abertillery, S.O., Monmouthshire	June 8, 1895
771 Stobart, Frank, Biddick Hall, Fence Houses	S. Aug. 2, 1873 A.M. Aug. 5, 1882 M. June 8, 1889
772 Stobart, Henry Temple, Wearmouth Colliery, Sunderland	S. Oct. 2, 1880 A.M. Aug. 4, 1888 M. Aug. 3, 1889
773 Stobart, William Ryder, Etherley Collieries, County Durham	Oct. 11, 1890

		Date of Election and of Transfer.
774	STOKER, ARTHUR P., Ouston House, near Chester-le-Street	S. Oct. 6, 1877
		A.M. Aug. 1, 1885
		M. Aug. 3, 1889
775	STOKOE, JAMES, Herrington Lodge, West Herrington, *via* Sunderland	A. Nov. 24, 1894
		M. Dec. 10, 1904
776	STONE, ARTHUR, Heath Villas, Hindley, Wigan	June 13, 1896
777*	STONIER, GEORGE ALFRED, 726, Salisbury House, London, E.C.	June 11, 1904
778	STOREY, WILLIAM, Urpeth Villas, Beamish, S.O., County Durham	April 12, 1902
779	STOW, AUDLEY HART, Maybeury, McDowell County, West Virginia, U.S.A.	Feb. 13, 1909
780	STRAKER, J. H., Howden Dene, Corbridge, S.O., Northumberland	Oct. 3, 1874
781	STREATFIELD, HUGH SIDNEY, Ryhope, Sunderland ...	A.M. June 8, 1889
		M. Aug. 3, 1889
782	STUART, DONALD MCDONALD DOUGLAS, Redland, Bristol ...	June 8, 1895
783	SULMAN, HENRY LIVINGSTONE, 44, London Wall, London, E.C.	Feb. 11, 1899
784	SUMMERBELL, RICHARD, Preston Colliery, North Shields .	A. Dec. 9, 1905
		M. Dec. 14, 1907
785	SUTCLIFFE, RICHARD, Horbury, Wakefield	June 14, 1902
786	SUTHERLAND, EDGAR GREENHOW, West Rainton, Fence Houses	Dec. 10, 1904
787	SUTTON, WILLIAM, Grosmont, 46, Palace Road, Streatham Hill, London, S.W.	April 28, 1900
788	SWALLOW, JOHN, East Pontop Colliery, Annfield Plain, S.O., County Durham	May 2, 1874
789	SWALLOW, RALPH STOREY, Langley Park, Durham	A. Dec. 9, 1899
		M. Dec. 12, 1903
790	SWALLOW, WARDLE ASQUITH, Tanfield Lea, Tantobie, S.O., County Durham	S. Dec. 9, 1893
		A. Aug. 3, 1901
		M. Aug. 2, 1902
791	SWETE, OSWALD RICKETTS, Tugela Gold-mine, *via* Greytown, Natal, South Africa	June 9, 1906
792	SWINBURNE, UMFREVILLE PERCY, Inspector of Mines, Pretoria, Transvaal	A.M. Aug. 4, 1894
		M. June 14, 1902
793	SWINDLE, JACKSON, West House, Swalwell Road, Dunston, Gateshead-upon-Tyne	June 14, 1902
794	SWINNEY, ALFRED JOHN GEORGE, Lorne Villa, Elm Road, Sidcup, S.O., Kent	June 11, 1898
795	SYMONS, FRANCIS, Ulverston	Feb. 11, 1899
796	TALLIS, JOHN FOX, The Firs, Ebbw Vale, S.O., Monmouthshire	Dec. 12, 1903
797	TATE, SIMON, Trimdon Grange Colliery, County Durham (*Member of Council*)	Sept. 11, 1875
798	TATE, WALKER OSWALD, Usworth Hall, Washington, S.O., County Durham	S. Oct. 12, 1895
		A. Aug. 1, 1903
		M. Feb. 13, 1904
799	TAYLOR, ALFRED HENRY, Puponga Colliery, Collingwood, Nelson, New Zealand	Dec. 14, 1901
800	TAYLOR, NEIL, c/o The Falmouth Consolidated Mines, Limited, Wheal Jane Mine, Baldhu, near Truro ...	April 13, 1907
801	TAYLOR, THOMAS, Chipchase Castle, Wark, S.O., Northumberland	July 2, 1872
802	TEASDALE, THOMAS, Middridge, Heighington, S.O., County Durham	April 9, 1892
803	TELFORD, WILLIAM HAGGERSTONE, Hedley Hope Collieries, Tow Law, S.O., County Durham	S. Oct. 3, 1874
		A.M. Aug. 6, 1881
		M. June 8, 1889
804	TENNANT, JOHN THOMAS, James Street, Hamilton, Newcastle, New South Wales, Australia	Dec. 12, 1903
805	TERRY, ARTHUR MICHAEL, 1, Clifton Road, Newcastle-upon-Tyne	Aug. 6, 1904

		Date of Election and of Transfer.
806	TEUTENBERG, WILLIAM	June 8, 1907
807	THOM, ARCHIBALD, Jun., Moresby Parks, near Whitehaven	Aug. 5, 1905
808	THOMAS, ARTHUR, 10, Florence Terrace, Falmouth ...	Aug. 7, 1897
809	THOMAS, DAVID, Quay Street, Ammanford, S.O., Carmarthenshire	June 20, 1908
810	THOMAS, ERNEST HENRY, Oakhill, Gadlys, Aberdare ...	Feb. 10, 1900
811	THOMAS, ILTYD EDWARD, Glanymor, Swansea	Feb. 10, 1900
812	THOMAS, J. J., Hawthorn Villa, Kendal	June 21, 1894
813	THOMAS, RICHARD, Cambria Villa, Stockton, New South Wales, Australia	Feb. 11, 1899
814	THOMLINSON, WILLIAM, Seaton Carew, West Hartlepool ...	April 25, 1896
815	THOMPSON, ALFRED, Todwick House, Sheffield	Dec. 13, 1902
816	THOMPSON, ERRINGTON, Weardale House, St. John's Chapel, S.O., County Durham	June 8, 1907
817	THOMPSON, JOHN WILLIAM, East Holywell Colliery, Shiremoor, Newcastle-upon-Tyne	A. June 10, 1893 M. Feb. 10, 1900
818	THOMPSON, WILLIAM, 1 and 2, Great Winchester Street, London, E.C.	Aug. 4, 1888
819	THOMSON, JOHN, Eston Mines, by Middlesbrough	April 7, 1877
820	THOMSON, JOHN WHITFIELD	Oct. 11, 1902
821	THOMSON, THOMAS, Westport Coal Company, Limited, Denniston, New Zealand	Feb. 8, 1908
822	THORNTON, NORMAN MUSCHAMP, Seaton Burn and Dinnington Collieries, Seaton Burn, Dudley, S.O., Northumberland...	S. April 27, 1895 A. Aug. 2, 1902 M. June 10, 1903
823	TINSLEY, JAMES, Belgrave House, Brecon Road, Abergavenny	Dec. 12, 1903
824	TODD, JOHN THOMAS, Blackwell Collieries, Alfreton ...	S. Nov. 4, 1876 A.M. Aug. 1, 1885 M. June 8, 1889
825*	TOWNSEND, HARRY POYSER, New Kleinfontein Company, Limited, Benoni, Transvaal	April 12, 1902
826	TRELEASE, WILLIAM HENWOOD, Via dei Cattaneo, Novara, Italy ; and Ceppomorelli per Macugnaya, Vall' Anzasca, Prov. di Novara, Italy	April 8, 1893
827	TREVOR, EARLE WELLINGTON JENKS, c/o Nonex Safety Tank Company, 46, Dover Street, Piccadilly, London, W. ...	Aug. 2, 1902
828	TROTMAN, HENRY LEIGH, Moorland House, Aspull, Wigan	Feb. 13, 1904
829	TULIP, SAMUEL, Bunker Hill, Fence Houses	June 12, 1897
830	TURNBULL, JOHN JAMES, Jharia P.O., District Manbhoom, Bengal, India	Feb. 12, 1898
831	TURNBULL, ROBERT, Usworth Colliery, Washington, S.O., County Durham	Aug. 2, 1902
832	TURNER, CHARLES EDWARD, Mina Campanario, Valverde del Camuio, Provincia de Huelva, Spain	A.M. Aug. 6, 1898 M. June 20, 1908
833	TUXEN, PETER VILHELM, 60, Market Street, Melbourne, Victoria, Australia	April 7, 1906
834	TWEDDELL, GEORGE HERBERT, Edenholme, Beverley Gardens, Cullercoats, Whitley Bay, S.O., Northumberland	Feb. 13, 1904
835*	TYERS, JOHN EMANUEL, Lowland Villa, 19, Wellington Street, Swindon, Wiltshire	A.M. Dec. 10, 1877 M. Aug. 3, 1889
836	TYZACK, DAVID, Bellingham, S.O., Northumberland ...	Feb. 14, 1874
837	UPTON, PRESCOTT, P.O. Box 1026, Johannesburg, Transvaal	June 12, 1897
838	VARTY, THOMAS, Skelton Park Mines, Skelton-in-Cleveland, S.O., Yorkshire	Feb. 12, 1887
839	VAUGHAN, CEDRIC, Hodbarrow Iron-ore Mines, Millom, S.O., Cumberland	Dec. 10, 1892
840	VEASEY, HARVEY C., Saxonhurst, Sea Road, Boscombe, Salisbury	June 21, 1894
841	VERNY, GEORGE, Pont d'Aubenas, Ardéche, France ...	Oct. 8, 1898
842	VERSCHOYLE, WILLIAM DENHAM, Tanrago, Ballisodare, S.O., County Sligo	Dec. 11, 1897

		Date of Election and of Transfer.
843	WADHAM, WALTER FRANCIS AINSLIE, Millwood, Dalton-in-Furness, S.O., Lancashire	Dec. 10, 1898
844	WALES, HENRY THOMAS, Bank Chambers, Castle Square, Swansea	Feb. 11, 1893
845	WALKER, HENRY, H.M. Inspector of Mines, Durham ...	June 8, 1907
846	WALKER, JAMES HOWARD, Bank Chambers, Wigan ...	Dec. 9, 1899
847	WALKER, JOHN SCARISBRICK, Pagefield Iron Works, Wigan	Dec. 4, 1869
848	WALKER, SYDNEY FERRIS, Bloomfield Crescent, Bath ...	June 11, 1898
849	WALKER, THOMAS A., Pagefield Iron Works, Wigan ...	June 8, 1895
850	WALKER, WILLIAM EDWARD, Lowther Street, Whitehaven	Nov. 19, 1881
851	WALL, HENRY, Tower Buildings, Wallgate, Wigan ...	June 8, 1895
852	WALL, WILLIAM HENRY, Cumberland, British Columbia ...	June 14, 1902
853	WALSH, GEORGE PATON, 143, Stadhouderskade, Amsterdam, Holland	Nov. 24, 1894
854	WALTON, JONATHAN COULTHARD, Writhlington Colliery, Radstock, Bath	S. Nov. 7, 1874 A.M. Aug. 6, 1881 M. June 8, 1889
855	WALTON, WILLIAM HENRY, Bridgewater Offices, Walkden, Manchester	June 10, 1903
856	WARD, ALEXANDER HOUSTONNE, Raneegunge, Bengal, India	April 14, 1894
857*	WARD, THOMAS HENRY, Giridih, E.I.R., Bengal, East India	A.M. Aug. 5, 1882 M. Aug. 3, 1889
858	WATERS, STEPHEN, Apartado No. 96, Pachuca, Mexico ...	April 4, 1903
859	WATKYN-THOMAS, WILLIAM, Egremont, S.O., Cumberland	A.M. Feb. 10, 1883 M. Aug. 3, 1889
860	WATSON, CLAUDE LESLIE, The Eastern Coal Company, Limited, Bhansjora P.O., E. I. Railway, Bengal, India	Dec. 8, 1900
861	WATSON, EDWARD The Cedars, Brereton, Rugeley	S. Feb. 13, 1892 M. Aug. 4, 1894
862	WATSON, JOHN, Outtrim Colliery Office, Victoria, Australia	Dec. 12, 1908
863	WATSON, THOMAS, Trimdon Colliery, S.O., County Durham	Oct. 11, 1890
864	WATTS, FRANK REGINALD, Blytheswood North, Osborne Road, Newcastle-upon-Tyne	Oct. 12, 1907
865	WATTS, J. WHIDBOURNE, P.O. Box 179, Barberton, Transvaal	Dec. 12, 1896
866	WEBSTER, ALFRED EDWARD, Manton, Worksop	June 12, 1897
867	WEDDERBURN, CHARLES MACLAGAN, 8, East Fettes Avenue, Edinburgh	Oct. 14, 1905
868	WEED, WALTER HARVEY, 42, Broadway, New York City, U.S.A.	June 14, 1902
869	WEEKS, JOHN GEORGE, Bedlington, S.O., Northumberland (PAST-PRESIDENT, *Member of Council*)	Feb. 4, 1865
870	WEEKS, RICHARD LLEWELLYN, Willington, S.O., County Durham (*Member of Council*)	A.M. June 10, 1882 M. Aug. 3, 1889
871*	WEINBERG, ERNEST ADOLPH, 39, Queen Street, Melbourne, Victoria, Australia	A.M. Feb. 12, 1898 M. Oct. 8, 1898
872	WELSH, THOMAS, Plas Darran, Abercynon, Pontypridd ...	Feb. 14, 1903
873	WELTON, WILLIAM PITT, Santa Ana, Departamento del Tolima, Republic of Colombia, South America	Dec. 9, 1905
874	WELTON, WILLIAM SHAKSPEARE, Elm Road, Wembley, S.O., Middlesex	Dec. 14, 1901
875	WESTERN, CHARLES ROBERT, Queen Anne's Mansions, Westminster, London, S.W.	June 10, 1893
876	WESTMACOTT, PERCY GRAHAM BUCHANAN, Rose Mount, Sunninghill, Ascot	June 2, 1866
877	WHITE, CHARLES EDWARD, Wellington Terrace, South Shields	S. Nov. 4, 1876 A.M. Aug. 1, 1885 M. Aug. 3, 1889
878	WHITE, FREDERICK NAPIER, H.M. Inspector of Mines, 12, St. James' Gardens, Swansea	June 11, 1898
879	WHITE, HENRY, Walker Colliery, Newcastle-upon-Tyne ...	S. March 2, 1867 M. Aug. 5, 1871

		Date of Election and of Transfer.
880	WHITEHEAD, JOHN JAMES, 20, Victoria Street, Westminster, London, S.W.	Oct. 10, 1903
881	WHYEL, GEORGE, First National Bank Building, Uniontown, Pennsylvania, U.S.A.	Aug. 1, 1908
882	WIDDAS, C., North Bitchburn Colliery, Howden, Darlington	Dec. 5, 1868
883	WIDDAS, HENRY, Whitehaven Castle Estate, Somerset House, Whitehaven	April 7, 1906
884	WIDDAS, PERCY, Oakwood, Cockfield, S.O., County Durham	Aug. 6, 1904
885	WIGHT, EDWARD SEPTIMUS, Taupiri Coal-mines, Limited. Mine-manager's Office, Huntly, near Auckland, New Zealand	A. Dec. 12, 1885 M. Aug. 3, 1889
886	WIGHT, FREDERICK WILLIAM, 5, Bondicar Terrace, Blyth	Aug. 5, 1905
887	WIGHT, ROBERT TENNANT, Oakhurst North, Benton, Newcastle-upon-Tyne	Oct. 13, 1900
888	WILBRAHAM, ARTHUR GEORGE BOOTLE, 28, Ovington Square, London, S.W.	S. Dec. 11, 1897 M. Feb. 8, 1902
889	WILD, MATTHEW BROWN, 37, Arthur Road, Erdington, Birmingham	Oct. 12, 1907
890	WILKINS, WILLIAM GLYDE, Westinghouse Building, Pittsburg, Pennsylvania, U.S.A.	Dec. 11, 1897
891	WILKINSON, MAURICE HEWSON, c/o Mackenzie and Company, Limited, Chungking, West China, *via* Siberia, Pekin and Hankow	A. Dec. 12, 1903 M. Oct. 10, 1908
892*	WILKINSON, WILLIAM FISCHER, 43, Threadneedle Street, London, E.C.	Oct. 10, 1896
893	WILLEY, JOSEPH LEONARD, P.O. Box 19, Potchefstroom, Transvaal	Aug. 1, 1908
894	WILLIAMS, ARTHUR HAMILTON, c/o Burrakur Coal Company, Panuria P.O., *via* Sitarampur, Bengal, India	Oct. 10, 1908
895	WILLIAMS, FOSTER, Miniera di Libiola, Sestri Levante, Italy	A. April 13, 1907 M. June 20, 1908
896	WILLIAMS, GRIFFITH JOHN, H.M. Inspector of Mines, Bangor	Aug. 2, 1902
897	WILLIAMS, ISAAC, Grasmere, S.O., Westmorland	April 13, 1907
898	WILLIAMS, JAMES, c/o James Pollock, Sons and Company, Limited, 3, Lloyd's Avenue, London, E.C.	April 11, 1908
899	WILLIAMS, JOHN, Dolavon, Llanrwst, S.O., Denbighshire	Oct. 8, 1904
900	WILLIAMS, JAMES WILSON, 15, Valley Drive, Harrogate	April 4, 1903
901	WILLIAMS, LUKE, Claremont, Moonah, Tasmania	April 10, 1897
902	WILLIAMS, ROBERT, 30, Clements Lane, Lombard Street, London, E.C.	June 13, 1896
903	WILLIS, HENRY STEVENSON, Medomsley, S.O., County Durham	S. Feb. 13, 1892 A. Aug. 4, 1900 M. June 8, 1907
904	WILSON, ANTHONY, Thornthwaite, Keswick	A.M. Feb. 10, 1900 M. Dec. 13, 1902
905	WILSON, ARCHIBALD LAURENCE, The New Ravenswood, Limited, Ravenswood, Queensland, Australia	A.M. June 12, 1897 M April 2, 1898
906	WILSON, FREDERICK, Hebburn Colliery, Hebburn, S.O., County Durham	Dec. 12, 1908
907	WILSON, JAMES, Wellington House, Edmondsley, Durham	April 13, 1901
908	WILSON, LLOYD, Flimby Colliery, Maryport	Jan. 19, 1895
909	WILSON, NATHANIEL, 2, East India Avenue, Leadenhall Street, London, E.C.	Dec. 9, 1899
910	WILSON, PEREGRINE OLIVER, c/o F. F. Wilson, 7, Devonshire Square, Bishopsgate Street, London, E.C.	Dec. 9, 1893
911	WILSON, ROBERT GOTT, Battle Green, Pelton Fell, S.O., County Durham	A. Aug. 6, 1892 M. Dec. 12, 1903
912	WILSON, WILLIAM, Chilton Colliery, *via* Ferry Hill	June 8, 1907
913	WILSON, WILLIAM BRUMWELL, Horden Dene, Easington, Castle Eden, S.O., County Durham	S. Feb. 6, 1869 M. Aug. 2, 1873
914*	WILSON, WILLIAM BRUMWELL, Jun., 162, Westmoreland Road, Newcastle-upon-Tyne	Feb. 9, 1901
915	WINCHELL, HORACE V., 505, Palace Building, Minneapolis, Minnesota, U.S.A.	Nov. 24, 1894

		Date of Election and of Transfer.
916	WITT, OTTO, Narvik, Norway	April 9, 1904
917	WOOD, ERNEST SEYMOUR, Cornwall House, Murton, S.O., County Durham	Oct. 10, 1891
918	WOOD, JOHN, Coxhoe Hall, Coxhoe, S.O., County Durham	S. June 8, 1889 A. Aug. 4, 1894 M. Aug. 3, 1895
919*	WOOD, SIR LINDSAY, Bart., The Hermitage, Chester-le-Street (PAST-PRESIDENT, *Member of Council*)	Oct. 1, 1857
920	WOOD, RICHARD, Barley Brook Foundry, Wigan	June 14, 1902
921	WOOD, ROBERT, 8, Olympia Gardens, Morpeth	April 13, 1907
922	WOOD, THOMAS, North Hetton Colliery Office, Moorsley, Hetton-le-Hole, S.O., County Durham	S. Sept. 3, 1870 M. Aug. 5, 1871
923	WOOD, THOMAS OUTTERSON, Cramlington House, Cramlington, S.O., Northumberland	Feb. 14, 1903
924	WOOD, WILLIAM HENRY, Coxhoe Hall, Coxhoe, S.O., County Durham	Aug. 6, 1857
925	WOOD, WILLIAM OUTTERSON, South Hetton, S.O., County Durham (PAST-PRESIDENT, *Member of Council*)	Nov. 7, 1863
926	WOODBURNE, THOMAS JACKSON, Bultfontein Mine, De Beers Consolidated Mines, Limited, Kimberley, South Africa	Feb. 10, 1894
927	WOODESON, WILLIAM ARMSTRONG, Clarke, Chapman and Company, Limited, Victoria Works, Gateshead-upon-Tyne	Dec. 10, 1904
928	WRIGHT, ABRAHAM, East Indian Railway, Engineering Department, Giridih, Bengal, India	Feb. 11, 1905
929	WRIGHTSON, SIR THOMAS, Bart., Stockton-upon-Tees	Sept. 13, 1873
930	WRIGHTSON, WILFRID INGRAM, Neasham Hall, Darlington	A.M. Dec. 9, 1899 M. Feb. 8, 1908
931	YEOMAN, THOMAS PRESSICK, Ballarpur, Chanda District, Central Provinces, India	Aug. 1, 1903
932	YOULL, GIBSON, Bulli, New South Wales, Australia	Oct. 12, 1901
933	YOUNG, HARBEN ROBERT, Marshlands, Henley Street, Westport, New Zealand	Feb. 9, 1901
934	YOUNG, JOHN ANDREW, 3, Fountain Avenue, Gateshead-upon-Tyne	A.M. Dec. 10, 1887 M. Aug. 3, 1889
935	YOUNG, JOHN HUNTLEY, Wearmouth Colliery, Sunderland	June 21, 1894

ASSOCIATE MEMBERS (Assoc. M.I.M.E.).

Marked ` have paid life composition.

		Date of Election and of Transfer.
1	AINSWORTH, GEORGE, The Hall, Consett, S.O., County Durham	Dec. 9, 1905
2	ARMSTRONG, JOHN HOBART, St. Nicholas' Chambers, Newcastle-upon-Tyne	Aug. 1, 1885
3	ATKINSON, GEORGE BLAXLAND, Prudential Assurance Buildings, Mosley Street, Newcastle-upon-Tyne	Nov. 5, 1892
4	BARRETT, WILLIAM SCOTT, Abbotsgate, Blundellsands, Liverpool	Oct. 14, 1899
5	BEAUCHAMP, FRANK B., Woodborough House, near Bath	Oct. 8, 1904
6*	BELL, SIR HUGH, Bart., Middlesbrough	Dec. 9, 1882
7	BISHOP, CLARENCE ADRIAN, Engineering and Building Works, Mooi River, Natal, South Africa	Oct. 10, 1903
8	BORRADAILE, NOEL COLLINGWOOD DICKSON, Farm Sabonabon, near Motor Mine, Gatooma, Rhodesia, South Africa	Oct. 12, 1907
9*	BROADBENT, DENIS RIPLEY, Royal Societies Club, St. James' Street, London, S.W. *Transactions* sent to The Library, Royal Societies Club, St. James' Street, London, S.W.	Oct. 14, 1899

Date of Election and of Transfer.

10 Brown, Edward Otto Forster, c/o Hugo Sherer, Jun., and Company, Calle Cadena 6, Mexico City, Mexico ... S. Dec. 14, 1901 A. Aug. 3, 1907 A.M. Oct. 12, 1907
11 Brutton, P. M., 17, Sandhill, Newcastle-upon-Tyne ... Oct. 13, 1900
12 Burn, Charles William, 28, Fawcett Street, Sunderland June 11, 1898

13 Cackett, James Thoburn, Pilgrim House, Newcastle-upon-Tyne ... ... Oct. 10, 1903
14 Capell, Rev. George Marie, Passenham Rectory, Stony Stratford ... ... Oct. 8, 1892
15*Carr, William Cochran, Benwell Colliery, Newcastle-upon-Tyne ... ... Oct. 11, 1890
16*Chewings, Charles, William Street, Hawthorn, South Australia ... ... April 25, 1896
17 Cochrane, Ralph D., Hetton Colliery Offices, Fence Houses. *Transactions* sent to W. Cochrane, The Willows, Willington, S.O., County Durham ... ... June 1, 1878
18 Cochrane, William James, York Chambers, Fawcett Street, Sunderland ... ... April 3, 1909
19 Cooper, R. W., Newcastle-upon-Tyne ... ... Sept. 4, 1880
20 Cope, William Henry, The University, Birmingham ... Dec. 9, 1905
21 Cory, Sir Clifford John, Bart., c/o Cory Brothers and Company, Limited, Cardiff ... ... Dec. 11, 1897
22 Coxon, Samuel, 1, Fern Gardens, Low Fell, Gateshead-upon-Tyne ... ... Feb. 13, 1909
23 Cruttenden, William Courtenay Dawes, 31A, Colmore Row, Birmingham ... ... June 11, 1904

24 Eccles, Edward, Milburn House, Newcastle-upon-Tyne ... Oct. 13, 1894
25 Edwards, F. Henry, Bath Lane, Newcastle-upon-Tyne ... June 11, 1887
26 Ellam, Albert Spencer, 16, Arlington Park Mansions, Chiswick, London, W ... ... April 25, 1896
27 Ellis, Oswald William, 49, Beaumont Fee, Lincoln ... Oct. 11, 1902

28 Fairless, Joseph, Wensleyville, Holywell Avenue, Monkseaton, Whitley Bay, S.O., Northumberland ... ... June 10, 1899
29 Fenwick, Featherstone, County Chambers, Westgate Road, Newcastle-upon-Tyne ... ... June 8, 1907
30 Ferguson, Colin Armstrong, P.O. Box 21, Randfontein, Transvaal ... ... July 14, 1896
31 Foster, T. J., Coal Exchange, Scranton, Pennsylvania, U.S.A. ... ... Dec. 12, 1891

32 George, Edward James, Beech Grove, Consett, S.O., County Durham ... ... Dec. 9, 1905
33 Gibson, George Ralph, Tyne Saw Mills, Hexham ... June 20, 1908
34 Gibson, Thomas William, Bureau of Mines, Toronto, Ontario, Canada ... ... June 8, 1901
35*Graham, John, Findon Cottage, near Durham ... ... Oct. 9, 1897
36 Graham, James Parmley, 26, Cloth Market, Newcastle-upon-Tyne ... ... Dec. 8, 1906
37 Guthrie, Reginald, Neville Hall, Newcastle-upon-Tyne (Treasurer, *Member of Council*) ... ... Aug. 4, 1888

38 Haanel, Eugene, Director of Mines, Department of Mines, Ottawa, Canada ... ... Aug. 1, 1903
39 Haggie, Arthur Jamieson, The Manor House, Long Benton, Newcastle-upon-Tyne ... ... Feb. 8, 1908
40 Haggie, Peter Norman Broughton, The Limes, Whitburn, Sunderland ... ... Oct. 10, 1908
41 Hall, Charles, 196, Gresham House, London, E.C. ... Dec. 9, 1905
42 Harris-Edge, H. P., Coalport Works, Shifnal ... June 8, 1901
43 Haswell, William Spence, Beverley Gardens, Cullercoats, Whitley Bay, S.O., Northumberland ... ... April 13, 1901

Date of Election and of Transfer.

44 HEDLEY, JOHN HUNT, John Street, Sunderland ... ... June 13, 1891
45 HEELEY, GEORGE, East Avenue, Benton, Newcastle-upon-Tyne ... ... Dec. 14, 1895
46 HENDERSON, CHARLES WILLIAM CHIPCHASE, c/o John George Weeks, Bedlington, S.O., Northumberland ... Dec. 9, 1882
47 HENZELL, ROBERT, Northern Oil Works, Newcastle-upon-Tyne ... ... April 11, 1891
48 HESKETH, RICHARD, Neville Hall, Newcastle-upon-Tyne ... Feb. 13, 1909
49 HODGETTS, ARTHUR, c/o G. W. Hodgetts, Vaal River Estate, Sydney, *via* Delpoort's Hope, District Kimberley, South Africa ... ... Oct. 9, 1897
50 HOPPER, GEORGE WILLIAM NUGENT, The Ropery, Thornaby-on-Tees, Stockton-on-Tees ... ... Oct. 10, 1908
51 HUMPHREYS-DAVIES, GEORGE, 5, Laurence Pountney Lane, Cannon Street, London, E.C. ... ... Oct. 8, 1892

52 INNES, THOMAS SNOWBALL, Prudential Buildings, Mosley Street, Newcastle-upon-Tyne ... ... Dec. 10, 1898

53 JAMES, HENRY M., Colliery Office, Whitehaven ... ... June 10, 1893
54 JEANS, JAMES STEPHEN, 165, Strand, London, W.C. ... April 2, 1898
55 JEFFREY, JOSEPH ANDREW, c/o The Jeffrey Manufacturing Company, Columbus, Ohio, U.S.A. ... ... Dec. 11, 1897
56 JEFFRIES, JOSHUA, Abermain Colliery, New South Wales, Australia ... ... Dec. 10, 1898
57*JOICEY, JAMES JOHN, 62, Finchley Road, St. John's Wood, London, N.W. ... ... Oct. 10, 1891

58 KIDSON, ARTHUR, c/o Glaholm and Robson, Limited, Rope Manufacturers, Sunderland ... ... April 8, 1899
59 KIRKLEY, JAMES, Cleadon Park, Cleadon, Sunderland ... June 8, 1907
60 KROHN, HERMAN ALEXANDER, 103, Cannon Street, London, E.C. ... ... Oct. 14, 1893

61 LAMB, EDMUND GEORGE, Borden Wood, Liphook, S.O., Hants. ... ... Feb. 12, 1898
62 LANGSLOW-COCK, EDWARD ARTHUR, H.M. Inspector of Mines, Mine Office, Seremban, Negri Sembilan, Federated Malay States ... ... Aug. 2, 1902
63 LATIMER, WILLIAM, 3, St. Nicholas' Buildings, Newcastle-upon-Tyne ... ... Oct. 14, 1905
64 LEAKE, PERCY COLLINSON, c/o Deanbank Chemical Company, Ferry Hill ... ... Aug 3, 1907
65 LISHMAN, GEORGE PERCY, Bunker Hill, Fence Houses ... Aug. 4, 1900
66 LOEWENSTEIN, HANS VON LOEWENSTEIN ZU, Friedrichstrasse, 2, Essen-Ruhr, Germany. *Transactions* sent to Bibliothek des Vereins für die bergbaulichen Interessen im Oberbergamtsbezirk Dortmund, Essen-Ruhr, Germany April 13, 1907

67 MARSHALL, PATRICK, University School of Mines, Dunedin, New Zealand ... ... June 12, 1897
68 MORRIS, PERCY COPELAND, 79, Elm Park Gardens, London, S.W. ... ... Feb. 14, 1903

69 OLIFF, THOMAS MILLEN, Transvaal Bischoff, Limited, Mine Office, Warm Baths, Waterberg, Transvaal ... ... April 3, 1909

70 PALMER, ALFRED MOLYNEUX, John Bowes and Partners, Limited, Milburn House, Newcastle-upon-Tyne ... Nov. 24, 1894
71*PICKUP, PETER WRIGHT DIXON, Rishton Colliery, Rishton, Blackburn ... ... Feb. 12, 1898
72 POSTLETHWAITE, JOHN, Chalcedony House, Eskin Place, Keswick ... ... Feb. 11, 1905

Date of Election and of Transfer.

73 Prior-Wandesforde, Richard Henry, Castlecomer House, Castlecomer, S.O., County Kilkenny ... ... Dec. 9, 1905
74*Proctor, John Henry, 29, Side, Newcastle-upon-Tyne ... June 8, 1889

75 Quince, William John, P.O. Box 343, Pietermaritzburg, Natal, South Africa ... ... April 8, 1905

76 Redmayne, Robert Norman, 14, Neville Street, Newcastle-upon-Tyne ... ... Dec. 8, 1906
77 Reid, Sidney, Printing Court Buildings, Newcastle-upon-Tyne ... ... Dec. 13, 1902
78 Ridley, James Cartmell, 1, Bentinck Terrace, Newcastle-upon-Tyne ... ... Feb. 11, 1893
79 Rogerson, John Edwin, Oswald House, Durham ... ... June 8, 1895
80 Russell, James, Westgate Road, Newcastle-upon-Tyne ... Feb. 13, 1904

81 Sadler, Basil, Craigmore, Lanchester, Durham ... ... Feb. 11, 1905
82 Samuel, David, Ynyswen, New Road, Llanelly ... ... Dec. 13, 1902
83 Sandberg, Christoph George Sigismund, 8, Velperbinnensingel, Arnhem, Holland ... ... Dec. 14, 1907
84 Sanders, Charles William Henry, Sherburn House, near Durham ... ... Dec. 14, 1901
85 Saunders, George B., Saunders, Todd and Company, Maritime Buildings, King Street, Newcastle-upon-Tyne ... Jan. 19, 1895
86 Schumacher, Raymond William, c/o H. Eckstein and Company, P.O. Box 149, Johannesburg, Transvaal ... April 9, 1904
87 Scott, John Oliver, Milburn House, Newcastle-upon-Tyne Dec. 11, 1897
88 Smith, Arthur Herbert, Broad Street House, London, E.C. ... ... June 14, 1902
89 Steuart, Douglas Stuart-Spens, Royal Societies Club, St. James' Street, London, S.W. ... ... June 10, 1899
90 Strange, Harold Fairbrother, P.O. Box 2527, Johannesburg, Transvaal ... ... Dec. 11, 1897
91 Strzelecki, Algernon Percy Augustus de, 39, Victoria Street, Westminster, London, S.W. ... ... Dec. 12, 1908

92 Todd, James, Overdale, Jesmond, Newcastle-upon-Tyne ... Aug. 6, 1892

93 Valentine, James, 1, West View, Horwich, S.O., Lancashire ... ... June 14, 1902
94 Voskule, Gideon A., P.O. Box 1803, Johannesburg, Transvaal ... ... Dec. 10, 1904

95 Waley, Frederick George, The Bellambi Coal Company, Limited, 9, Bridge Street, Sydney, New South Wales, Australia ... ... Feb. 9, 1907
96 Walker, Frederick Tillotson, 70, Pilgrim Street, Newcastle-upon-Tyne .. .. June 10, 1903
97 Wall, George Young, Halmote Court Office, New Exchequer Building, Durham .. .. Nov. 24, 1894
98 Walmesley, Oswald, 2, Stone Buildings, Lincoln's Inn, London, W.C. ... ... June 8, 1895
99 Welford, Thomas, Wallarah Colliery, Catherine Hill Bay, New South Wales, Australia ... ... June 10, 1903
100 Whitehead, Thomas, Brindle Lodge, Preston ... ... June 12, 1897
101 Williams, Henry, Llwyngwern, Pontardulais, S.O., Glamorgan ... ... Dec. 9, 1905
102*Wood, Arthur Nicholas Lindsay, The Hermitage, Chester-le-Street ... ... July 14, 1896

103 Young, Mrs. H. E., 617, Michigan Street, Victoria, British Columbia ... ... April 4, 1903

ASSOCIATES (Assoc. I.M.E.).

Marked * have paid life composition.

		Date of Election and of Transfer.
1	ALLAN, HERBERT DURHAM, Rewah State Collieries, Umaria, Central India, Bengal Nagpur Railway	Feb. 10, 1906
2	ANNETT, HUGH CLARKSON, Widdrington, Acklington, S.O., Northumberland	S. Feb. 15, 1906 A. June 20, 1908
3	ARCHER, MATTHEW WILLIAM, Grosvenor House, Manchester Road, Stocksbridge, Sheffield	S. June 8, 1895 A. Aug. 4, 1900
4	ARMSTRONG, HENRY, 29, William Street, New Seaham, Seaham Harbour, S.O., County Durham	Dec. 12, 1903
5	ARMSTRONG, WILLIAM, Jun., Chillaton Manganese-mines, Lewdown, S.O., Devon	S. June 11, 1898 A. Aug. 6, 1904
6	ASKEW, ALFRED HILL, 16, Telford Street, Gateshead-upon-Tyne	Feb. 9, 1907
7	BAMBOROUGH, JACOB, Preston Colliery, North Shields ...	Oct. 8, 1904
8	BARRETT, ROLLO SAMUEL, Whitehill Hall, Pelton Fell, S.O., County Durham	S. Dec. 9, 1905 A. Aug. 1, 1908
9	BATES, JOHNSON, 5, Grange Villa, S.O., County Durham ...	Feb. 11, 1905
10	BATES, THOMAS, West Wylam Terrace, Prudhoe, Ovingham, S.O., Northumberland	April 13, 1907
11	BATTEY, THOMAS, Station Road, Shiremoor, Newcastle-upon-Tyne	Oct. 13, 1894
12	BAYLDON, HAROLD CRESSWELL, Kotchkar, *via* Miass, Government of Orenburg, Russia	S. April 2, 1898 A. Aug. 3, 1901
13	BENSON, HERBERT SYDNEY, Whitehill Farm, Pelton Fell, S.O., County Durham	S. Feb. 11, 1905 A. Aug. 5, 1905
14	BEWICK, GEORGE, Johnson Terrace, West Auckland, Bishop Auckland	April 10, 1897
15	BEWLEY, THOMAS, Stobswood Colliery, Acklington, S.O., Northumberland	Aug. 5, 1905
16	BLAIR, ROBERT RICHMOND, 6, Hamilton Terrace, Whitehaven	Aug. 2, 1902
17	BLUNDEN, PHILIP SIDNEY, The Villas, Dean Bank, Ferry Hill Village, Ferry Hill	June 8, 1907
18	BOOTH, FREDERIC LANCELOT, Ashington Colliery, Morpeth	S. Feb. 10, 1894 A. Aug. 4, 1900
19	BOWES, THOMAS, Overdale, Catchgate, Annfield Plain, S.O., County Durham	Feb. 13, 1892
20	BRANDON, GEOFFRY, 9, Kensington Gardens, Monkseaton, Whitley Bay, S.O., Northumberland	S. Dec. 8, 1900 A. Aug. 3, 1907
21	BROWN, JOHN, Central Pench Coal Company, Limited, Pench Valley P.O., District Chindwara, C.P., India ...	S. June 8, 1907 A. Aug. 7, 1909
22	BURT, THOMAS, Hill House, Washington, Washington Station, S.O., County Durham	April 9, 1904
23	CARROLL, JOHN, Spring Bank House, Newfield, Willington, S.O., County Durham	Feb. 12, 1898
24	CHAPMAN, JOHN, Tyzack Street, Edmondsley, Durham ...	Dec. 14, 1907
25	CHARLTON, WILLIAM JOHN, Jun., H.M. Inspector of Mines, 32, Western Hill, Durham	April 12, 1902
26	CHEESMAN, MATTHEW FORSTER, Throckley Colliery, Newburn, S.O., Northumberland	S. Dec. 13, 1902 A. Aug. 5, 1905
27	CLARK, NATHANIEL J., Belle Vue, Chester-le-Street ...	S. April 13, 1901 A. Aug. 1, 1903
28	CLARK, THOMAS, Dipton Colliery, Lintz Green Station, County Durham	Oct. 11, 1890
29	CLIFFORD, EDWARD HERBERT, Rand Club, Johannesburg, Transvaal	S. Oct. 13, 1894 A. Aug. 6, 1898
30	CLIVE, ROBERT, Bentley Colliery, near Doncaster	S. Feb. 10, 1900 A. Aug. 1, 1903
31	CLOUGH, EDWARD STOKOE, Bomarsund House, Bomarsund, Bedlington, S.O., Northumberland	Feb. 14, 1903

		Date of Election and of Transfer.
32	COADE, SAMUEL, Steel Green, Millom, S.O., Cumberland ...	Dec. 10, 1904
33	COCKBAIN, TOM STEWARTSON, Usworth Colliery, Washington Station, S.O., County Durham	Dec. 8, 1906
34	COCKBURN, JOHN, Fatfield Road, Washington, S.O., County Durham	April 9, 1904
35	COOK, GEORGE, Binchester Hall, Bishop Auckland	S. Aug. 2, 1902 A. Aug. 5, 1905
36	COWX, H. F., Hilly View, Thornley, S.O., County Durham	April 14, 1894
37	COXON, SAMUEL GEORGE, Hamsteels Colliery, Durham ...	Feb. 9, 1901
38	COXON, WILLIAM BILTON, Seaton Hill, Boosbeck, S.O., Yorkshire	S. Feb. 12, 1898 A. Aug. 2, 1902
39	CRAWFORD, THOMAS, Eighton Banks, Gateshead-upon-Tyne	Dec. 8, 1906
40	CROWLE, PERCY, Mysore Mine, Marikuppam, Mysore State, India	Feb. 11, 1905
41	CUMMINGS, WILLIAM, Beamish View, Stanley, S.O., County Durham	Dec. 14, 1907
42	DAGLISH, FRANK, 1, Wilson Terrace, Broughton Moor, Maryport	Dec. 14, 1907
43	DANSKIN, THOMAS, Springwell Colliery, Gateshead-upon-Tyne	Dec. 10, 1898
44	DAVIES, DANIEL JOHN, The Pines, Corrimal, New South Wales, Australia	Oct. 12, 1907
45	DAVIS, JAMES E., South Medomsley Colliery, Dipton, S.O., County Durham	Feb. 12, 1898
46	DAVISON, FRANCIS, Ash Grove House, Hedley Hill Colliery, near Waterhouses, Durham	Feb. 12, 1898
47	DICK-CLELAND, ARCHIBALD FELCE, c/o Bank of Montreal, Mexico City, Mexico. *Transactions* sent to Ria Ora, Trelawny Road, Camborne	Dec. 8, 1906
48	DIXON, GEORGE, 14, Queens Square, Eastwood, Nottingham	S. Feb. 9, 1901 A. Aug. 3, 1907
49	DUNNETT, SAMUEL, West View House, Coomassie Road, Waterloo, Blyth	June 8, 1895
50	EADIE, JOHN ALLAN, Jun., Eller Bank, Harrington, S.O., Cumberland	S. Oct. 10, 1903 A. Aug. 5, 1905
51	ELLIOT, ARTHUR, Springfield, Cressington Park, Liverpool	S. Dec. 13, 1902 A. Aug. 1, 1908
52	ELLIOTT, GEORGE, South View, Mickley Colliery, Stocksfield, S.O., Northumberland	June 8, 1907
53	EMMERSON, THOMAS, East Jherria Coal Company, Limited, Goluckdih Colliery, Jherria P.O., Manbhoom, India ...	Oct. 12, 1907
54	ENGLISH, THOMAS WEDDLE, Halton Colliery, Whittington, Corbridge, S.O., Northumberland...	Feb. 11, 1905
55	ESKDALE, JOHN, Ashington Colliery, Morpeth	Oct. 11, 1902
56	FAIRBROTHER, CHARLES JAMES, Norman House, Broomhill, Acklington, S.O., Northumberland	Feb. 8, 1908
57	FALCON, MICHAEL, Llanarth Villas, Cross Keys, Newport, Monmouthshire	S. Oct. 13, 1894 A. Aug. 4, 1900
58	FIELD, BENJAMIN STARKS, Layabad Colliery, Kusunda P.O., District Manbhoom, Bengal, India ...	S. Aug. 2, 1902 A. Aug. 3, 1907
59	FOGGO, JOHN FREDERICK, Old Hall, Denby, Derby... ...	S. June 14, 1902 A. Aug. 6, 1904
60	FORD, THOMAS, Blaydon Burn Colliery, Blaydon-upon-Tyne, S.O., County Durham	Aug. 2, 1902
61	FORSTER, EDWARD BATY, 15, Grange Road, Ryton, S.O., County Durham	April 7, 1906
62	FORSTER, FRANK, Black Hills Road, Horden Colliery, Castle Eden, S.O., County Durham	Feb. 8, 1902
63	FOWLER, ROBERT NORMAN, Staindrop House, Station Road, New Washington, Washington Station, S.O., County Durham	S. Aug. 2, 1902 A. Aug. 3, 1907

	Date of Election and of Transfer.
64 GALLAGHER, PATRICK, Clifton Row, Netherton Colliery, Nedderton, Newcastle-upon-Tyne...	Dec. 13, 1902
65 GILCHRIST, GEORGE ATKINSON, 17, Eldon Place, Newcastle-upon-Tyne	S. Dec. 14, 1901 A. Aug. 1, 1908
66 GOODENOUGH, WALTER EASOM, Rose Cottage, Burnopfield, S.O., County Durham	Feb. 8, 1908
67 GORE-LANGTON, ROBERT LANCELOT, Hatch Park, Taunton	Feb. 10, 1906
68 GRAHAM, ROBERT, 31, Railway Terrace, Willington, S.O., County Durham	Oct. 12, 1907
69 GREENWELL, GEORGE HAROLD, c/o Kilburn and Company, 4, Fairlie Place, Calcutta, India	S. Dec. 12, 1903 A. Aug. 4, 1905
70 GREY, JOHN NEIL, 20, St. Mary's Terrace, Ryton, S.O., County Durham	June 10, 1905
71 GUY, JOHN GEORGE, Manor House, Wardley Colliery, Newcastle-upon-Tyne	Dec. 8, 1906
72 HALL, JOSEPH PERCIVAL, Talbot House, Birtley, S.O., County Durham	S. Oct. 9, 1897 A. Aug. 2, 1902
73 HAMPSON, ALEXANDER, Windlestone Colliery, Ferry Hill	Feb. 12, 1898
74 HANDYSIDE, WILLIAM, Jun., 4, Brandling Terrace, Felling, S.O., County Durham	June 12, 1897
75 HARPER, GEORGE OCTAVIOUS, Greenhead, Chopwell Colliery, Lintz Green, County Durham	S. Feb 8, 1902 A. Aug 3, 1907
76 HAWES, GEORGE ARTHUR, 2, Sandringham Terrace, Leeholme, Bishop Auckland	Dec. 12, 1903
77 HEAPS, CHRISTOPHER, c/o The Newsham Colliery Company, Limited, Winston, Darlington	S. Feb. 10, 1900 A. Aug. 4, 1906
78 HEDLEY, GEORGE WILLIAM, Alexander Terrace, Coach Lane Houses, Dinnington Colliery, Dudley, S.O., Northumberland	Dec. 13, 1902
79 HEDLEY, MORTON, Medomsley Colliery, Medomsley, S.O., County Durham	Feb. 13, 1909
80 HEDLEY, ROWLAND FRANK HUTTON, East Cramlington, Cramlington, S.O., Northumberland	S. April 4, 1903 A. Aug. 7, 1909
81 HENDERSON, WILLIAM, 20, Station Avenue, Fence Houses	Oct. 12, 1901
82 HERRIOTTS, JOSEPH GEORGE, Tasra Colliery, Bhugudih, B.N.R., Bengal, India	April 28, 1900
83 HERRON, EDWARD, 4, Holly Terrace, Stanley, S.O., County Durham	Feb. 15, 1896
84 HESLOP, JAMES, Stobswood Colliery, Acklington, S.O., Northumberland	Dec. 12, 1908
85 HESLOP, WARDLE, Wyncote, Holywell Avenue, Monkseaton, Whitley Bay, S.O., Northumberland	S. Dec. 10, 1904 A. Aug. 7, 1909
86 HESLOP, WILLIAM, High Grange, Howden-le-Wear, S.O., County Durham	Oct. 8, 1898
87 HORNSBY, DEMSTER, Choppington Colliery, Scotland Gate, Morpeth	Feb. 12, 1898
88 HUDSON, MARK, 115, Gurney Valley, Bishop Auckland ...	Dec. 9, 1905
89 HUDSPETH, HENRY MOORE, c/o John William Hudspeth, Willington, S.O., County Durham	S. Oct. 12, 1907 A. Feb. 13, 1909
90 HUGHES, THOMAS, Fan Terrace, Urpeth Busty, Birtley, S.O., County Durham	Feb. 10, 1906
91 HUMBLE, JOHN NORMAN, Linden House, Beamish, S.O., County Durham	S. Aug. 2, 1902 A. Aug. 5, 1905
92 HUMBLE, WILLIAM HENRY, Seafield House, Risehow, Maryport	Dec. 14, 1907
93 HUNTER, ANDREW, 2, Abbotsford Terrace, South Shields ...	Feb. 13, 1897
94 IMRIE, HENRY MARSHALL, 22, Western Hill, Durham ...	Feb. 14, 1903
95 JEFFERY, ALBERT JOHN, 8, Agents Terrace, Boldon Colliery, S.O., County Durham	April 28, 1900

	Date of Election and of Transfer.
96 JOBLING, JOHN SWANSTONE, 10, Langley Street, Langley Park, Durham	Oct. 12, 1907
97 JOHNSON, THOMAS, The Villas, Dean Bank, Ferry Hill	Dec. 9, 1905
98 JOHNSON, WILLIAM, Banks House, Church Street, Durham	Aug. 6, 1892
99 JONES, WALTER, c/o Mrs. Fenwick, The Farm, Wheatley Hill Colliery, Thornley, S.O., County Durham	S. Feb. 9, 1901 A. Aug. 1, 1908
100 KIPLING, JOSEPH WILLIAM, 1, Station Road, West Cornforth, S.O., County Durham	Dec. 12, 1908
101 LASCELLES, PERCY LINDSAY, Augusta Terrace, Whitburn, Sunderland	June 20, 1908
102 LASCELLES, WALTER REGINALD, Pench Valley Coal Company, Chindwara, Central Provinces, India	Feb. 8, 1908
103 LAWSON, JOHN, 32, Prince Road, Tow Law, S.O., County Durham	Oct. 10, 1908
104 LEWISS, EDWARD MIDDLEMASS, 3, Eighth Row, Ashington, Morpeth	Oct. 12, 1907
105 LIDDELL, CHRISTOPHER, Houghton Main Colliery, near Barnsley	S. Dec. 14, 1901 A. Aug. 6, 1904
106 LIGHTLEY, JOHN, Byers Green, Spennymoor	April 25, 1896
107 LOGAN, REGINALD SAMUEL MONCRIEFF, 33, Boyd Terrace, Blucher Pit, Newburn, S.O., Northumberland	S. Feb. 9, 1901 A. Aug. 1, 1903
108 LONGRIDGE, JOHN, 12, St. James' Terrace, Morpeth	Feb. 11, 1905
109 LOWRY, JOSEPH THOMPSON, 22, Montreal Street, Cleator Moor, S.O., Cumberland	April 3, 1909
110 MCCARTHY, MICHAEL DODDS, 63, D Street, Perkinsville, Pelton Fell, S.O., County Durham	Dec. 14, 1901
111 MCDONALD, FRANCIS, 9, Neale Street, Annfield Plain, S.O., County Durham	Oct. 13, 1906
112 MACGREGOR, DONALD, Seghill Colliery, Seghill, Dudley, S.O., Northumberland	S. Feb. 9, 1901 A. Aug. 1, 1908
113 MCGREGOR, JOHN EDWARD, 49, Eden Terrace, Oxhill, Stanley, S.O., County Durham	S. April 4, 1903 A. Aug. 1, 1903
114 MARR, JAMES EDMUND, High Spen, Newcastle-upon-Tyne	Feb. 8, 1908
115 MASON, BENJAMIN, Burnopfield Colliery, Burnopfield, S.O., County Durham	April 11, 1891
116 MELVILLE, JOHN THOMAS, 4, Poplar Gardens, Gosforth, Newcastle-upon-Tyne	April 8, 1899
117 MILBURN, EDWIN WALTER, 4, First Row, Ashington, Morpeth	S. Feb. 10, 1900 A. Aug. 5, 1905
118 MILBURN, WILLIAM, Hill House, Ouston, Birtley, S.O., County Durham	June 8, 1895
119 MILBURNE, JOHN ETHERINGTON, East View, Dalton-on-Tees	S. Oct. 14, 1899 A. Aug. 6, 1904
120 MILLER, ALEXANDER, South Greta Colliery, near West Maitland, New South Wales, Australia	Oct. 10, 1903
121 MILLNE, DAVID, 1, Burdon Street, Bedlington, S.O., Northumberland	Aug. 3, 1907
122 MINNS, THOMAS TATE, Jun., Binchester Blocks, Bishop Auckland	S. April 10, 1897 A. Aug. 1, 1903
123 MINTO, GEORGE WILLIAM, Harraton Colliery, Chester-le-Street	Oct. 10, 1891
124*MITCHELL-WITHERS, WILLIAM CHARLES, P.O. Box 2969, Johannesburg, Transvaal	S. April 28, 1900 A. Aug. 2, 1902
125 MORSON, FARRER WILLIAM, Glenholm, Crook, S.O., County Durham	Aug. 4, 1900
126 MUSGROVE, WILLIAM, Heddon Colliery, Northumberland	S. June 8, 1895 A. Aug. 1, 1903
127 MYCOCK, WILLIAM, Shotton Colliery, Castle Eden, S.O., County Durham	Oct. 10, 1908
128 NELSON, GEORGE CATRON, Greenhead Terrace, Chopwell Colliery, Ebchester, S.O., County Durham	Feb. 8, 1902

	Date of Election and of Transfer.
129 Nichols, Henry Herbert, Kibblesworth, Gateshead-upon-Tyne	Aug. 3, 1907
130 Oliver, Ernest Hunter, Denewell Avenue, Low Fell, Gateshead-upon-Tyne	S. Feb. 8, 1902 A. Aug 1, 1908
131 Oswald, George Robert, c/o The Labuan Coal-fields Company, Limited, Borneo. All communications to be sent to E. William Oswald, 14, Victoria Road, Whitehaven	S. June 9, 1900 A. Aug. 3, 1907
132 Owen, William Rowland, The Sangli Gold-mines, Limited, Gadag, Bombay Presidency, India	Feb. 12, 1898
133 Paddon, Neville Blackmore, Benalee House, Raneegunge, E.I. Railway, Bengal, India	Dec. 14, 1907
134 Palmer, Harry, The Manor House, Medomsley, S.O., County Durham	S. June 14, 1902 A. Aug. 7, 1909
135 Palmer, Meyrick, Jobs Hill, near Crook, S.O., County Durham	S. June 8, 1901 A. Aug. 1, 1908
136 Parrington, Henry Mason, Dene House, Castletown, Sunderland	S. Feb. 13, 1904 A. Aug. 3, 1907
137 Pattison, Andrew, Greenside, Ryton, S.O., County Durham	Dec. 8, 1906
138 Pattison, Charles Arthur, High Grange, Howden-le-Wear, S.O., County Durham	S. April 13, 1901 A. Aug. 5, 1905
139 Pattison, William, Horsley House, East Stanley, Stanley, S.O., County Durham	Dec. 13, 1902
140 Paul, James, The Oaks, Lochgelly, S.O., Fife	Oct. 10, 1908
141 Pearson, John Charlton, Hotchpudding Farm, Denton, Scotswood, S.O., Northumberland	Feb. 14, 1903
142 Peel, George, Jun., 27, Langley Street, Langley Park, Durham	April 4, 1903
143 Phelps, Charles, 193, Noel Street, Nottingham	Aug. 3, 1901
144 Potts, Laurance Wylam, c/o Mrs. Glover, 36, Marine Approach, South Shields	April 4, 1903
145 Pratt, George Ross, Springwell Colliery, Gateshead-upon-Tyne	June 8, 1895
146 Proctor, Thomas, Woodhorn Colliery, Morpeth	Oct. 13, 1894
147 Pumphrey, Charles Ernest, Greenside House, Ryton, S.O., County Durham	S. Dec. 10, 1904 A. Aug. 4, 1906
148 Ramsay, John Gladstone, 2, Steavenson Street, Bowburn, Coxhoe, S.O., County Durham	Dec. 10, 1892
149 Ratcliffe, Robert, 14, Ben Street, Alfreton Road, Nottingham	Aug. 3, 1907
150 Richardson, Benjamin, 29, Westcott Terrace, Deanbank, Ferry Hill	April 7, 1906
151 Richardson, Frank, Lynwood, Richmond Street, Ashton-under-Lyne	S. Oct. 12, 1901 A. Aug. 1, 1908
152 Richardson, Henry, Clara Vale Colliery, Ryton, S.O., County Durham	Dec. 8, 1906
153 Ridley, George Dinning, 14, First Row, Ashington, Morpeth	Feb. 8, 1890
154 Ridley, Henry Anderson, Burnbrae, Blaydon Burn, Blaydon-upon-Tyne, S.O., County Durham	Dec. 14, 1907
155 Ridley, William, Jun., Mary Pit, Blaydon-upon-Tyne, S.O., County Durham	Dec. 8, 1906
156 Ridpath, Tom R., Longshaw House, Billinge, Wigan	S. June 8, 1901 A. Aug. 4, 1906
157 Rivers, John, Bow Street, Thornley Colliery, Durham	Feb. 9, 1895
158 Robinson, John William, 3, The Terrace, Boldon Colliery, S.O., County Durham	S. April 12, 1902 A. Aug. 5, 1905
159 Robinson, Stanley, Bunker Hill, Fence Houses	S. Oct. 12, 1901 A. Aug. 1, 1908
160 Rochester, William, 1, Office Row, Netherton Colliery, Nedderton, Newcastle-upon-Tyne	Dec. 9, 1905

		Date of Election and of Transfer.
161	ROCHESTER, WILLIAM SIMM, 192, Canning Street, Newcastle-upon-Tyne	Feb. 13, 1904
162	ROGERS, JOHN, Widdrington Colliery, Acklington, S.O., Northumberland	S. April 8, 1899 A. Aug. 4, 1906
163	ROLFE, ROBERT, Falstone Colliery, Falstone, S.O., Northumberland	Dec. 9, 1905
164	ROOSE, HUBERT F. G., Royal School of Mines, South Kensington, London, S.W.	S. Dec. 9, 1899 A. Aug. 3, 1907
165	RUTHERFORD, ROBERT ARCHIBALD, Wellington Terrace, Edmondsley, Durham	Dec. 14, 1907
166	RUTHERFORD, THOMAS EASTON, West Shield Row Colliery, Stanley, S.O., County Durham	S. June 10, 1899 A. Aug. 4, 1906
167	SANER, CHARLES B., Turf Mines, Limited, P.O. Box 5887, Johannesburg, Transvaal	April 10, 1897
168	SCHOLLICK, THOMAS, 13, Model Street, New Seaham, Sunderland	Dec. 12, 1903
169	SCOBIE, ISAAC, Woonona, near Sydney, New South Wales, Australia	Oct. 13, 1906
170	SEED, ALEXANDER, 1, College Terrace, Brandon Colliery, S.O., County Durham	April 4, 1903
171	SEVERS, JONATHAN, 1, Quality Row, Ryhope, S.O., County Durham	S. June 8, 1895 A. Aug. 4, 1900
172	SHARP, THOMAS, Wilson Terrace, Broughton Moor, Maryport	Dec. 14, 1907
173	SIMPSON, RICHARD CHARLTON, Wellington Terrace, Edmondsley, Durham	Feb. 13, 1904
174	SMITH, ERNEST ARTHUR, H.M. Office of Works (Supplies Division), 18, Queen Anne's Gate, Westminster, London, S.W.	S. Dec. 9, 1905 A. Aug. 1, 1908
175	SNAITH, JOSEPH, South Pontop Colliery, Annfield Plain, S.O., County Durham	Oct. 12, 1907
176	SNOWDON, THOMAS, Jun., Oakwood, Cockfield, S.O., County Durham	S. June 12, 1897 A. Aug. 3, 1901
177	SOUTHERN, CHARLES, 12, Seward Terrace, Writhlington, Bath	S. June 10, 1903 A. Aug. 7, 1909
178	SOUTHERN, STEPHEN, Heworth Colliery, Felling, S.O., County Durham	S. Dec. 14, 1895 A. Aug. 3, 1901
179	STOBART, THOMAS CARLTON, Ushaw Moor Colliery, Durham	Aug. 2, 1902
180	STOKER, NICHOLAS, South Pelaw Colliery, Chester-le-Street	Feb. 13, 1904
181	STOKOE, JOHN GEORGE, Alston House, Crigglestone, Wakefield	Dec. 9, 1899
182	STRONG, GEORGE ADAMSON, 33, George Street, Birtley, S.O., County Durham	S. Aug. 2, 1902 A. Aug. 1, 1908
183	SWAN, WILLIAM EDWARD, Washington Colliery, County Durham	April 9, 1904
184	SWANN, JOSEPH TODD, 6, Victoria Terrace, Throckley, Newburn, S.O., Northumberland	S. Dec. 13, 1902 A. Aug. 4, 1906
185	TATE, ROBERT SIMON, Saint Hilda Colliery, South Shields...	S. Aug. 3, 1901 A. Aug. 4, 1906
186	TAYLOR, HERBERT WILLIAM, El Bote Mine, Zacatecas, Mexico	Aug. 2, 1902
187	THIRLWELL, THOMAS A., 18, Lynwood Avenue, Bentinck Road, Newcastle-upon-Tyne	S. Dec. 13, 1902 A. Aug. 7, 1909
188	THIRTLE, JAMES, Grant Street, Horden, Sunderland	Oct. 10, 1908
189	THOMPSON, WILLIAM, Stone House, Broughton Moor, Maryport	Dec. 14, 1907
190	THORNTON, FRANK, Cornsay Colliery, Durham	S. Feb. 8, 1902 A. Aug. 7, 1909
191	TURNBULL, WILLIAM, West Holywell, Backworth Colliery, Newcastle-upon-Tyne	Oct. 8, 1904

		Date of Election and of Transfer.
192	TURNER, GEORGE, Widdrington Colliery, Widdrington, Acklington, S.O., Northumberland	June 8, 1895
193	TWEDDELL, JOHN SMITH, Seaton Delaval Colliery, Northumberland	S. Feb. 13, 1897 A. Aug. 1, 1903
194	WAINWRIGHT, WILLIAM, Heworth Colliery, Felling, S.O., County Durham	April 2, 1898
195	WALKER, JOSEPH NOEL, 33, Sherburn Terrace, Consett, S.O., County Durham	S. Aug. 6, 1904 A. Aug. 1, 1908
196	WALTON, ARTHUR JOHN, Bettisfield Colliery, Bagillt, S.O., Flintshire	S. Feb. 12, 1898 A. Aug. 1, 1903
197	WALTON, HARRY, Durham Road, Consett, S.O., County Durham	Dec. 10, 1904
198	WALTON, ISAAC, Dovenby, Cockermouth	Dec. 14, 1907
199	WARDLE, ROBERT, Edgewell Terrace, Prudhoe, Ovingham, S.O., Northumberland	April 13, 1907
200	WELSH, ARTHUR, Red House, Tunstall Village, near Sunderland	S. Aug. 1, 1896 A. Aug. 1, 1903
201	WHINN, JOHN, High Spen, Newcastle-upon-Tyne	Feb. 8, 1908
202	WHITFIELD, THOMAS CUTHBERT, Trimdon Grange Colliery, County Durham	Oct. 8, 1904
203	WIDDAS, FRANK, Beechburn Grange, Howden-le-Wear, S.O., County Durham	Dec. 8, 1900
204	WIDOWFIELD, JOHN GILBERT, Wellington Terrace, Edmondsley, Durham	Dec. 14, 1907
205	WILD, ROBERT POWLEY, c/o R. H. Moore, St. Day, Scorrier, S.O., Cornwall	S. Dec. 8, 1906 A. Aug. 1, 1908
206	WILSON, HUGH, Bajupanee Collieries, Pench Valley P.O., Chindwara District, Central Provinces, India	Feb. 13, 1904
207	WOOD, GEORGE, Dudley Colliery, Dudley, S.O., Northumberland	April 13, 1907
208	WRAITH, ALFRED OSBORN, 73, Lyons Terrace, Hetton-le-Hole, S.O., County Durham	S. June 9, 1900 A. Aug. 1, 1908
209	YIELDER, HUGH LISHMAN, 14, Moor View, Ryton, S.O., County Durham	April 7, 1906
210	YOUNG, GEORGE ELLIS, Kimblesworth Colliery, Chester-le-Street	S. Aug. 3, 1901 A. Aug. 5, 1905

STUDENTS (Stud.I.M.E.).

		Date of Election.
1	ADAM, THOMAS WALTER, Christ Church Vicarage, Whitehaven	April 3, 1909
2	ARMSTRONG, GEORGE PRIMROSE KENNEDY, The Elms, Gosforth, Newcastle-upon-Tyne	Dec. 12, 1908
3	AVERY, WILLIAM ERNEST, 4, Prospect Terrace, Low Fell, Gateshead-upon-Tyne	June 8, 1907
4	BARBER, NORMAN ELSDALE, Seghill Colliery, Seghill, Dudley, S.O., Northumberland	June 20, 1908
5	BELL, JOHN VALENTINE, 226, Old Farm, Ouston, Chester-le-Street	Dec. 14, 1907
6	BROOKS, DOUGLAS ROY, 83, Victoria Road, Jarrow	Dec. 14, 1907
7	BRYDON, ANDREW DEMPSTER, 7, Ravensbourne Terrace, South Shields	Dec. 8, 1906
8	CALLAND, WILLIAM, Hedley Hope Collieries, Tow Law, S.O., County Durham	April 7, 1906
9	COXON, SAMUEL BAILEY, Washington Colliery, Washington Station, S.O., County Durham	Oct. 12, 1907
10	DAKERS, EDGAR WALTON, Tudhoe Colliery, Spennymoor	Dec. 14, 1907
11	DANIELL, HENRY EDMUND BLACKBURNE, 8, Ashfield Terrace, Ryton, S.O., County Durham	Aug. 3, 1907

Date of Election.

12 Douglas, Albert Edward, Beethoven House, Horden, Castle Eden, S.O., County Durham ... ... Aug. 1, 1903

13 Earnshaw, Oscar, Kiln Bank House, Amble, Acklington, S.O., Northumberland ... ... Feb. 8, 1908
14 Evans, Vincent, Great Houghton, Barnsley ... ... Dec. 12, 1908

15 Ford, Eric Loufwin, Whittonstall House, Chopwell, Ebchester, S.O., County Durham ... ... April 11, 1908
16 Fowler, Albert Ernest, Usworth Villa, Washington Station, S.O., County Durham ... ... Oct. 12, 1907

17 Grace, William Grace, Hall Garth Hall, Winlaton, Blaydon-upon-Tyne, S.O., County Durham ... ... Feb. 9, 1907
18 Graham, William, Jun., Solway House, Moresby, Whitehaven Oct. 13, 1906

19 Hawkins, John Bridges Bailey, Staganhoe Park, Welwyn ... Dec. 13, 1902
20 Hepburn, Henry, Greenhead Terrace, Chopwell, Ebchester, S.O., County Durham ... ... Oct. 12, 1907
21 Herdman, Fred., 7, Chatsworth Parade, Low Fell, Gateshead-upon-Tyne ... ... Dec. 14, 1907
22 Huggup, Ralph, 33, Wingrove Road, Newcastle-upon-Tyne ... Feb. 10, 1906
23 Hull, Tom Edward, 11, Clarence Terrace, Regent's Park, London, N.W. ... ... Dec. 12, 1908
24 Hunter, Herbert Stanley, Blakelaw, Kenton, Newcastle-upon-Tyne ... ... Feb. 9, 1907
25 Hutton, Allan Robinson Bowes, Bentley Colliery, near Doncaster ... ... April 8, 1905
26 Hyde, George Alfred, 96, New Row, New Delaval, Newsham, S.O., Northumberland ... ... Feb. 13, 1909

27 Kirkup, Ernest Hodgson, Eighton Lodge, Low Fell, Gateshead-upon-Tyne ... ... April 13, 1907

28 Lawson, Richard Forster, Holmside Villa, Holmside, Edmondsley, Durham ... ... Feb. 13, 1904
29 Liddell, Henry Norman John, Prudhoe House, Prudhoe, Ovingham, S.O., Northumberland ... ... June 10, 1905
30 Lister, John Alfred, Linden House, Carlton Terrace, Spennymoor ... ... Dec. 8, 1906

31 Maughan, Thomas, Tudhoe Colliery Office, Spennymoor ... Dec. 14, 1907
32 Muse, Thomas John, Jun., 1, Brook Terrace, Birtley, S.O., County Durham ... ... Dec. 8, 1906

33 Nicholson, George Thompson, Dene House, Scotswood, S.O., Northumberland ... ... Dec. 10, 1904

34 Prest, Norman Leslie, East Cramlington, Cramlington, S.O., Northumberland ... ... April 11, 1908

35 Rayner, Sydney, West Lodge, Oxton, Cheshire ... ... Feb. 13, 1909
36 Ridley, William, 10, Railway Street, Tow Law, S.O., County Durham ... ... Aug. 1, 1908
37 Ritson, John Anthony Sydney, Burnhope Colliery, Lanchester, Durham ... ... Aug. 4, 1906

38 Scott, John Linton, The Grange, East Holywell, Shiremoor, Newcastle-upon-Tyne ... ... Dec. 12, 1908
39 Sharp, Charles Gordon, Riding Mill, S.O., Northumberland .. Feb. 10, 1906
40 Simpson, Joseph, Wheatley Hill Colliery Office, Thornley, S.O., County Durham ... ... June 10, 1905
41 Slater, Thomas Edward, Blaydon Burn Colliery, Blaydon-upon-Tyne, S.O., County Durham ... ... April 13, 1907

Date of Election.

42 Thomas, Robert Clark, Houghton Colliery, Houghton-le-Spring, S.O., County Durham ... ... Aug. 3, 1907
43 Thompson, George Heron Dinsdale, Dinsdale Vale, Windsor Avenue, Waterloo, Blyth ... ... Feb. 14, 1903
44 Turnbull, John James, Jun., 60, Beaconsfield Street, Blyth ... Feb. 8, 1908

45 Varvill, Wilfred Walter, 12, Eldon Place, Newcastle-upon-Tyne ... ... Dec. 12, 1908

46 Walton-Brown, Stanley, Seghill Colliery, Seghill, Dudley, S.O., Northumberland ... ... June 20, 1908
47 Watson, Thomas, Jun., Rosebank, Darlington ... ... June 8, 1907
48 Watts, Hubert, Blytheswood North, Osborne Road, Newcastle-upon-Tyne ... ... June 8, 1907
49 Weeks, Francis Mathwin, Eastwood Collieries, near Nottingham ... ... Feb. 10, 1906
50 Welch, William Hall, Old Farm, Ouston, Birtley, S.O., County Durham ... ... Feb. 10, 1906
51 Wilkinson, Ralph Percy, 51, Railway Terrace, New Herrington, Fence Houses ... ... Dec. 9, 1905
52 Williamson, George Armstrong, 101, Warwick Street, Heaton, Newcastle-upon-Tyne ... ... Feb. 13, 1909
53 Wraith, Charles Osborn, Thornley Colliery Office, Thornley, S.O., County Durham ... ... June 10, 1905
54 Wrightson, Philip B. H., 6, Leazes Crescent, Hexham ... April 11, 1908

SUBSCRIBERS.

1 Owners of Ashington Colliery, Newcastle-upon-Tyne.
2 Birtley Iron Company (3), Birtley, S.O., County Durham.
3 The Broken Hill Proprietary Company, Limited, 3, Great Winchester Street, London, E.C.
4 Brunner, Mond and Company, Limited, Northwich.
5 The Most Honourable the Marquess of Bute, Bute Estate Offices, Aberdare.
6 The Charlaw and Sacriston Collieries Company, Limited, 34, Grey Street, Newcastle-upon-Tyne.
7 Cowpen Coal Company, Limited (2), F, King Street, Newcastle-upon-Tyne.
8 The Honourable Lord Ninian Edward Crichton-Stuart, House of Falkland, Falkland, S.O., Fifeshire.
9 Crompton and Company, Limited, Pearl Buildings, Northumberland Street, Newcastle-upon-Tyne.
10 Dominion Coal Company, Limited, Glace Bay, Nova Scotia.
11 The Right Honourable the Earl of Durham (2), Lambton Offices, Fence Houses.
12 The Right Honourable the Earl of Ellesmere (2), Bridgewater Offices, Walkden, Manchester. *Transactions* sent to John Henry Vaughan Hart-Davis, Bridgewater Offices, Walkden, Manchester.
13 Elswick Coal Company, Limited, Newcastle-upon-Tyne.
14 D. H. and G. Haggie, Wearmouth Patent Rope Works, Sunderland.
15 Harton Coal Company, Limited (3), Harton Collieries, South Shields.
16 Hetton Coal Company (5), Fence Houses.
17 James Joicey and Company, Limited (2), Newcastle-upon-Tyne.
18 Lambton Collieries, Limited (2), E, Queen Street, Newcastle-upon-Tyne.
19 The Most Honourable the Marquess of Londonderry (5), c/o Vincent Charles Stuart Wortley Corbett, Londonderry Offices, Seaham Harbour.
20 Mavor and Coulson, Limited, 47, Broad Street, Mile-End, Glasgow.
21 North Brancepeth Coal Company, Limited, Crown Street Chambers, Darlington.
22 Owners of North Hetton Colliery (3), Fence Houses.
23 Osbeck and Company, Pit Timber Merchants, Newcastle-upon-Tyne.

24 Rand Mines, Limited, The Corner House, Johannesburg, Transvaal.
25 Ryhope Coal Company (2), Ryhope Colliery, Sunderland.
26 Owners of Seghill Colliery, Seghill, Dudley, S.O., Northumberland.
27 Siemens Brothers and Company, Limited, 39, Collingwood Buildings, Newcastle-upon-Tyne.
28 Société Houillère de Liévin (Pas-de-Calais), Liévin, Pas-de-Calais, France.
29 Owners of South Hetton and Murton Collieries (2), 50, John Street, Sunderland.
30 Owners of Stella Colliery, Hedgefield, Blaydon-upon-Tyne, S.O., County Durham.
31 Owners of Throckley Colliery, Newcastle-upon-Tyne.
32 Owners of Victoria Garesfield Colliery, Victoria Garesfield Colliery, Lintz Green, County Durham. *Transactions* sent to H. Peile, Priestman's Collieries, Limited, Milburn House, Newcastle-upon-Tyne.
33 Owners of Wearmouth Colliery (2), Sunderland.
34 Westport Coal Company, Limited (2), Dunedin, New Zealand.

ENUMERATION.

	August 7, 1909.
Honorary Members	22
Members	935
Associate Members	103
Associates	210
Students	54
Subscribers	34
Total	1,358

Members are desired to communicate all changes of address, or any corrections or omissions in the list of names, to the Secretary.

INDEX TO VOL. LIX.

Explanations.

The — at the beginning of a line denotes the repetition of a word; and in the case of Names, it includes both the Christian Name and the Surname; or, in the case of the name of any Firm, Association or Institution, the full name of such Firm, etc.

Discussions are printed in *italics*.

"Abs." signifies Abstracts of Foreign Papers at the end of the Proceedings.

"App." signifies Annual Report of the Council, etc., at the end of the Volume.

A.

Abel, Walter Robert, *circulation and heat absorption in steam boilers*, 24.

Absorption, heat, circulation and, in steam boilers, 23.

Accidents, Germany, Prussia, collieries, electrical installations, 1907, abs. 103.

Accounts, 9; app. iii., xi.

Africa, Algeria, Oran, southern, coal-measures, abs. 22.

—, —, phosphatic deposits, abs. 23.

—, Angola, petroleum, abs. 29.

—, French Congo, copper, silicate of, new, abs. 24.

—, — —, Kwilu - Niari, cupriferous region, abs. 25.

—, German South-west, Tsumeb, ore-deposits, abs. 28.

—, Natal, effect of igneous dyke on coal-seam, 38.

—, Orange Free State, petroleum, abs. 72.

—, Portuguese West, Angola, petroleum, abs. 29.

—, South, diamantiferous deposits, abs. 70.

—, Tunis, phosphatic deposits, abs. 23.

Ahlburg, Joh., mineral resources of Spain and Portugal, abs. 8.

Ahnert, E., M. Ivanov, A. Khlaponin, and P. Rippas, recent surveys in gold-bearing regions of Siberia, abs. 21.

Anatolia, mineral resources, abs. 69.

Annett, Hugh Clarkson, hydraulic stowing of gob at Shamrock I. and II. colliery, Herne, Westphalia, Germany, 111.—*Discussion*, 129.

Annett, Hugh Clarkson, working of inclined seams in St. Étienne coal-field, at Montrambert and La Béraudière collieries, 56.—*Discussion*, 110.

Annual general meeting, 1.

— — —, thirteenth, The Institution of Mining Engineers, 135.

— report of council, 3; app. iii., v.

— — — finance committee, 7; app. iii., x.

Anti-breakage appliances, coal-shipment and laying-out of staithe heads, with special reference to, 136.

Arabistan, mineral resources, abs. 69.

Argentine Republic, Salagasta, coal, abs. 30.

Aron, A., underground fires in mines, abs. 100.

Associate members, election, 22, 46, 93, 109.

— —, list, app. iii., xlvi.

Associates, election, 22, 46, 94, 109, 253.

—, list, app. iii., l.

Atkinson, J. B., report on circumstances attending explosion at Washington "Glebe" colliery, on 20th February, 1908.—*Discussion*, 54.

Auriferous deposits, Russian Empire, Siberia, Yenisei region, abs. 67.

Austria-Hungary, Hungary, Almásszelistye, ore-deposits, abs. 56.

— —, —, Dobschau, ore-deposits, abs. 58.

— —, —, eastern, bauxite-deposits, abs. 66.

B.

Bagnoli, Ugo, repairing leaky seams, 31.—Discussion, 33, 94.
Barometer, thermometer, etc., readings, 1907, abs. 105.
—, —, —, —, 1908, abs. 105.
Bärtling, R., unwatering of strata and subsidences in Rhenish-Westphalian coal-field, abs. 91.
Baumberger, E., iron-ores in Swiss Jura, abs. 63.
Bauxite-deposits, Austria-Hungary, Hungary, eastern, abs. 66.
Bedson, P. Phillips, awarded G. C. Greenwell medal, 14.
—, *note on deposit of sulphur in colliery water*, 42.
—, *notes on small contrivance to more easily detect fire-damp*, 282.
Belgium, La Mallieue, zinc-ores, abs. 51.
—, phosphate-mining, abs. 83.
Bella Union quicksilver-mines, Mexico, abs. 36.
Blackett, W. C., notes on small contrivance to more easily detect fire-damp, 130.—Discussion, 131, 279.
—, *report on causes of and circumstances attending underground fire at Hamstead colliery*, 47, 51, 52, 53.
—, — — *circumstances attending explosion at Washington "Glebe" colliery*, 54, 57, 58.
Bleeck, A. W. G., jadeite-deposits of Upper Burma, abs. 17.
Boilers, steam, circulation and heat absorption in 23.
Bold box-controller and box-switch, 35.
Bolivia, stanniferous deposits, abs. 74.
Borax-deposits, Peru, Salinas, abs. 39.
Boule, Marcellin, discovery of coal in Madagascar, abs. 60.
Box-controller and box-switch, Bold, 35.
Box-switch and box-controller, Bold, 35.
Brazil, Ouro Preto, zinc-blende deposits, abs. 31.
—, Paraná region, coal-outcrops, abs. 33.
—, southern, coal, search for, abs. 31.
Brine-springs, Russian Empire, Siberia, Yenisei basin, abs. 20.
Brown-coal deposits, Chile, abs. 34.
— — —, —, Cobquecura, abs. 34.
Burma, Nanya-Zeik, ruby-deposits, abs. 19.
—, Upper, jadeite-deposits, abs. 17.
Butureanu, V. C., manganiferous iron-ore deposits of Brosteni, Rumania, abs. 61.

C.

Cargo-steamers, coal, short description of various types, and of Doxford's new self-discharging steamer, 254.
Chesneau, G., Müller safety-lamp, abs. 95.
—, new French glass for safety-lamps, abs. 95.
Chile, brown-coal deposits, abs. 34.
—, Cobquecura, brown-coal deposits, abs. 34.
—, lignite deposits, abs. 34.
China, Yunnan, southern, coal-mines, abs. 15.
Christensen, P. F., *short description of various types of coal cargo-steamers and of Doxford's new self-discharging steamer*, 276.
Circulation and heat absorption in steam-boilers, 23.
Coal, Argentine Republic, Salagasta, abs. 30.
—, Brazil, southern, search for, abs. 31.
—, brown, Chile, abs. 34.
—, —, —, Cobquecura, abs. 34.
—, Madagascar, discovery, abs. 60.
—, United States of America, Colorado, abs. 49.
Coal cargo-steamers, short description of various types, and of Doxford's new self-discharging steamer, 254.
Coal-dust explosion, France, Bouches du Rhône, Gardanne mine, abs. 96.
— — or fire-damp, explosions, fatal and non-fatal, United Kingdom, list, 1908, abs. 105.
Coal-fields, France, St. Étienne, Montrambert and La Béraudière collieries, working of inclined seams, 56, 110.
— —, Germany, Rhenish-Westphalian, unwatering of strata and subsidences, abs. 91.
— —, Poland, Russian, Dombrowa, abs. 60.
— — —, —, —, fossil plants, abs. 80.
— —, Spain, León, Guardo, abs. 1.
Coal-measures, Africa, Algeria, Oran, southern, abs. 22.
Coal-mines, China, Yunnan, southern, abs. 15.
Coal-mining, Russian Empire, Siberia, south-western, Akmolinsk district, Kirghese Steppe, 99.
Coal-outcrops, Brazil, Paraná region, abs. 33.
Coal-seams, inclined, in St. Étienne coal-field, at Montrambert and La Béraudière collieries, working of, 56, 110.
— —, jurassic, Russian Empire, Siberia, Bureia basin, abs. 68.

Coal-seams, Natal, effect of igneous dyke on, 38.
Coal-shipment and the laying-out of staithe heads, with special reference to anti-breakage appliances, 136.
Coal-wedging machine, König and Gützlaff, abs. 88.
Cobalt, Mexico, Jalisco, abs. 38.
Colliery water, deposit of sulphur in, 41.
Committees, 1909-1910, app. iii., xvi.
Controller, box-, and box-switch, Bold, 35.
Copiapite, jánosite identified with, abs. 82.
Copper, silicate of, new, Africa, French Congo, abs. 24.
Corbett, V. W., *old wooden pumps found in Rainton colliery*, 92.
Costa, João Carlos da, petroleum in Angola, Portuguese West Africa, abs. 25.
Council, annual report, 3; app. iii., v.
— of The Institution of Mining Engineers, election of representatives on, 14.
Counillon, —, H. Lantenois, L. Laurent, H. Mansuy, and R. Zeiller, coal-mines, etc., of southern Yunnan, China, abs. 15.
Cupriferous deposits, Germany, Thuringian States, Franconian Forest, abs. 53.
— —, Spain, León, Palencia, northern, abs. 2.
— region, Africa, French Congo, Kwilu-Niari, abs. 25.
Czarnocki, S. J., Dombrowa coal-field, Russian Poland, abs. 60.

D.

Deposit of sulphur in colliery water, 41.
Diamantiferous deposits, South Africa, abs. 70.
Douvillé, H., and R. Zeiller, coal-measures in southern Oran, Algeria, abs. 22.
Doxford, A. E., *short description of various types of coal cargo-steamers and of Doxford's new self-discharging steamer*, 275.
Doxford, W., *short description of various types of coal cargo-steamers and of Doxford's new self-discharging steamer*, 277.
Doxford's new self-discharging steamer, short description of, 254.
Ducloux, E. Herrero, Salagasta coal, Argentine Republic, abs. 30.
Dueñas, Enrique J., mineral resources of department of Cuzco, Peru, abs. 40.
Dust-explosion, France, Bouches du Rhône, Gardanne mine, abs. 96.
Dyke, igneous, effect of, on Natal coal-seam, 38.

E.

Edlinger, W., tin-ore deposits of Herberton district, Queensland, abs. 78.
Effect of igneous dyke on Natal coal-seam, 38.
Election of members, 15, 22, 45, 93, 109, 253.
— — officers, 1.
— — representatives on council of The Institution of Mining Engineers, 14.
Electric safety-lamp experiments, Germany, Camphausen, abs. 93.
Electrical installations, Germany, Prussia, collieries, accidents, 1907, abs. 103.
Explosion, dust-, France, Bouches du Rhône, Gardanne mine, abs. 96.
—, Washington "Glebe" colliery, 54.
Explosions, collieries, Germany, Prussia, 1907, abs. 98.
—, fire-damp or coal-dust, fatal and non-fatal, United Kingdom, list, 1907, abs. 105.
—, — — — — —, — — — —, — —, —, 1908, abs. 105.

F.

Finance committee, annual report, 7; app. iii., x.
Fire, underground, at Hamstead colliery, report on causes of and circumstances attending, 47.
Fire-damp, notes on small contrivance to more easily detect, 130, 279.
— — or coal-dust, explosions, fatal and non-fatal, United Kingdom, list, 1907, abs. 105.
— — — — —, —, — — — —, — —, —, 1908, abs. 105.
Fires, underground, in mines, abs. 100.
Forster, T. E., *coal-mining on Kirghese Steppe, in Akmolinsk district of south-western Siberia*, 107.
—, *hydraulic stowing of gob at Shamrock I. and II. colliery, Herne, Westphalia, Germany*, 129.
—, *notes on small contrivance to more easily detect fire-damp*, 132, 133, 134.
—, *old wooden pumps found in Rainton colliery*, 92.
—, reading, writing, and smoke rooms, 134.

Forster, T. E., *report on causes of and circumstances attending underground fire at Hamstead colliery*, 47, 52, 53.
—, — — *circumstances attending explosion at Washington "Glebe" colliery*, 57.
—, *working of inclined seams in St. Étienne coal-field, at Montrambert and La Béraudière collieries*, 110.
Fossil plants, coal-field, Poland, Russian, Dombrowa, abs. 80.
France, Bouches du Rhône, Gardanne mine, dust-explosion, abs. 96.
France, Britanny, Côtes du Nord, Forest of Lorges, iron-ores, abs. 52.
—, safety-fuzes, abs. 89.
—, St. Étienne coal-field, working of inclined seams at Montrambert and La Béraudière collieries, 56, 110.
French glass, new, for safety-lamps, abs. 95.
Futers, T. C., *report on causes of and circumstances attending underground fire at Hamstead colliery*, 52.
Fuzes, safety, France, abs. 89.

G.

General meeting, thirteenth annual, The Institution of Mining Engineers, 135.
— meetings, 1, 22, 45, 93, 109, 253.
Georgiadesite, new plumbarseniferous mineral, abs. 81.
Gerasimov, A., recent surveys in gold-bearing regions of Siberia, abs. 22.
Germany, Bavaria, Fichtelgebirge, specular iron-ore, abs. 55.
—, Camphausen, electric safety-lamp experiments, abs. 93.
—, Eisenzeche iron-ore belt, abs. 54.
—, Prussia, collieries, electrical installations, accidents, 1907, abs. 103.
—, —, —, explosions, 1907, abs. 98.
—, Rhenish-Westphalian coal-field, unwatering of strata and subsidences, abs. 91.
Germany, Thuringian States, Franconian Forest, cupriferous deposits, abs. 53.
—, — —, — —, nickeliferous deposits, abs. 53.
—, Westphalia, Herne, Shamrock I. and II. colliery, hydraulic stowing of gob, 111.
Glass for safety-lamps, new French, abs. 95.
Glauber's salt-deposits, Russian Empire, Siberia, Yenisei basin, abs. 20.
Gob, hydraulic stowing of, Shamrock I. and II. colliery, Herne, Westphalia, Germany, 111.
Gold-bearing regions, Russian Empire, Siberia, surveys, recent, abs. 21.
Greenwell, G. C., medal, presentation of, 14.
Gypsum-deposits, metalliferous districts, Italy, Tuscany, abs. 64.

H.

Hamstead colliery, underground fire, report on causes of and circumstances attending, 47.
Hausse, R., surface and underground subsidence in coal-mining, abs. 91.
Headden, W. P., Colorado coal, United States of North America, abs. 49.
Heat absorption, circulation and, in steam boilers, 23.
Hedley, A. M., report of delegate to jubilee meeting of Société de l'Industrie Minérale, 1908, 15.
Heslop, William, *report on causes of and circumstances attending underground fire at Hamstead colliery*, 51.
Heslop, William Taylor, *note on effect of igneous dyke on Natal coal-seam*, 39.
Honorary members, list, app. iii., xviii.
Hydraulic stowing of gob, Shamrock I. and II. colliery, Herne, Westphalia, Germany, 111.

I.

Igneous dyke, effect of, on Natal coal-seam, 38.
Inclined seams in St. Étienne coal-field, at Montrambert and La Béraudière collieries, working of, 56, 110.
Institution of Mining Engineers, annual general meeting, thirteenth, 135.
—, election of representatives on council of, 14.
Iron-ore, specular, Germany, Bavaria, Fichtelgebirge, abs. 55.
Iron-ores, France, Britanny, Côtes du Nord, Forest of Lorges, abs. 52.
Iron-ores, Germany, Eisenzeche, abs. 54
— —, Rumania, Moldavia, Brosteni, abs. 61.
— —, Russia, Urals, southern, Komarovo, abs. 62.
— —, —, —, —, Zigaza, abs. 62.
— —, Swiss Jura, abs. 63.
Italy, Tuscany, metalliferous districts, gypsum-deposits, abs. 64.
—, Val di Bruna, lignite-deposits, abs. 58.
Ivanov, M., E. Ahnert, A. Khlaponin, and P. Rippas, recent surveys in gold-bearing regions of Siberia, abs. 21.

J.

Jadeite-deposits, Burma, Upper, abs. 17.
Jánosite identified with copiapite, abs. 82.
Jochamowitz, Alberto, borax-deposits of Salinas, Peru, abs. 39.
Jochamowitz, Alberto, mineral resources of Apurimac, Peru, abs. 86.
Jurassic coal-seams, Russian Empire, Siberia, Bureia basin, abs. 68.

K.

Kellner, G. J., petroleum in Orange River Colony, abs. 72.
Kerforne, F., iron-ores of Forest of Lorges, Britanny, abs. 52.
Khlaponin, A., jurassic coal-seams of Bureia basin, Siberia, abs. 68.
—, recent surveys in gold-bearing regions of Siberia, abs. 21.
Khlaponin, A., E. Ahnert, M. Ivanov, and P. Rippas, recent surveys in gold-bearing regions of Siberia, abs. 21.
Kirkup, J. P., *coal-mining on Kirghese Steppe, in Akmolinsk district of south-western Siberia*, 107.
—, *report on circumstances attending explosion at Washington "Glebe" colliery*, 59.
Kirsopp, John, Jun., coal-shipment and laying-out of staithe heads, with special reference to anti-breakage appliances, 136.
—, short description of various types of coal cargo-steamers and of Doxford's new self-discharging steamer, 254.—Discussion, 275.
König and Gutzlaff coal-wedging machine, abs. 88.
Koniushevsky, L., Zigaza and Komarovo iron-ore deposits, southern Urals, abs. 62.
Kurdistan, mineral resources, abs. 69.

L.

La Béraudière and Montrambert collieries, St. Étienne coal-field, working of inclined seams, 56, 110.
Lachmann, Richard, bauxite-deposits in eastern Hungary, abs. 66.
Lacroix, A., new silicate of copper from French Congo, abs. 25.
Lacroix, A., and A. de Schutten, georgiadesite, a new plumbarseniferous mineral, abs. 81.
Lantenois, H., — Counillon, L. Laurent, H. Mansuy, and R. Zeiller, coal-mines, etc., of southern Yunnan, China, abs. 15.
Laurent, L., — Counillon, H. Lantenois, H. Mansuy, and R. Zeiller, coal-mines, etc., of southern Yunnan, China, abs. 15.
Lawrence, Henry, memoir, 96.
—, portrait, *frontispiece*.
—, *repairing leaky seams*, 33.
Laying-out of staithe heads, coal-shipment and, with special reference to anti-breakage appliances, 136.
Leach, C. C., *report on causes of and circumstances attending underground fire at Hamstead colliery*, 47, 50, 53.
Leaky seams, repairing, 31, 94.
Levat, D., cupriferous region of Kwilu-Niari, French Congo, abs. 25.
Lignite deposits, Chile, abs. 34.
——, Italy, Val di Bruna, abs. 58.
Londonderry, The Most Noble the Marquess of, presentation of old wooden pumps found in Rainton colliery, 92.
Lotti, B., gypsum-deposits in metalliferous districts of Tuscany, abs. 64.
Louis, Henry, *coal-mining on Kirghes Steppe, in Akmolinsk district of south-western Siberia*, 107.
—, *notes on small contrivance to more easily detect fire-damp*, 281, 282.
—, *old wooden pumps found in Rainton colliery*, 92.
—, *report on circumstances attending explosion at Washington "Glebe" colliery*, 57, 58.
—, *safety-lamp for detecting small quantities of inflammable gas*, 46.
—, *short description of various types of coal cargo-steamers and of Doxford's new self-discharging steamer*, 275, 277.
Lozano, R. S., coal-basin of Guardo, Spain, abs. 1.
—, plumbiferous deposits of Sierra Nevada, Spain, abs. 13.
—, stanniferous deposits of Pontevedra province, Spain, abs. 14.

M.

Machado, Miguel R., lignite or brown-coal deposits of Chile, South America, abs. 34.
McLaren, John, *repairing leaky seams*, 33.
Madagascar, coal, discovery, abs. 60.
Mallada, L., mineral deposits in early and middle tertiary rocks of Spain abs. 6.

Manganese-ores, Spain, New Castille, Ciudad Real, abs. 3.
Manganiferous iron-ores, Rumania, Moldavia, Brosteni, abs. 61.
Mansuy, H., — Counillon, H. Lantenois, L. Laurent, and R. Zeiller, coal-mines, etc., of southern Yunnan, China, abs. 15.
Masters, V. F., petroliferous belt of northern Peru, abs. 72.
Maucher, W., Tsumeb ore-deposits, German South-west Africa, abs. 28.
Meister, A. K., auriferous deposits of Yenisei region, Siberia, abs. 67.
Members, election, 15, 22, 45, 93, 109, 253.
—, list, app. iii., xix.
Memoir, Henry Lawrence, 96.
Merivale, John H., memoir of Henry Lawrence, 96.
—, *notes on small contrivance to more easily detect fire-damp*, 133, 282.
Mexico, Bella Union quicksilver-mines, abs. 36.
—, Durango, Mapimí, sulphur-deposits, abs. 76.
—, Jalisco, cobalt, abs. 38.
Michael, R., manganese-ores of Ciudad Real, Spain, abs. 3.
Miller, J. H., *notes on small contrivance to more easily detect fire-damp*, 280, 282.
Mineral resources, Peru, Apurimac, abs. 86.
— —, —, Cuzco, abs. 40.
— —, —, Huamachuco, abs. 44.
— —, —, Huancavelica, abs. 42.
— —, —, Santiago de Chuco, abs. 47.
— —, Portugal, abs. 8.
— —, Spain, abs. 8.
Montrambert and La Béraudière collieries, St. Étienne coal-field, working of inclined seams, 56, 110.
Müller safety-lamp, abs. 95.

N.

Natal coal-seam, effect of igneous dyke on, 38.
Navarro, D. V., cobalt in state of Jalisco, Mexico, abs. 38.
Nicholson, J. H., *notes on small contrivance to more easily detect fire-damp*, 133.
—, *report on the causes of and circumstances attending an underground fire which occurred at Hamstead colliery*, 51, 53.
Nickeliferous deposits, Germany, Thuringian States, Franconian Forest, abs. 53.
Noble, T. G., *notes on small contrivance to more easily detect fire-damp*, 131, 133.
Novarese, V., lignite-deposits of Val di Bruna, Italy, abs. 58.
Nowomejsky, M. A., Glauber's salt-deposits and brine-springs in the Yenisei basin, Siberia, abs. 20.

O.

Officers, election, 1.
—, 1909-1910, app. iii., xvii.
Oliveira, E. P. de, coal-outcrops in Paraná region, Brazil, abs. 33.
Ore-deposits, Africa, French Congo, abs. 24.
— —, — —, Kwilu-Niari, abs. 25.
— —, —, German South-west, Tsumeb, abs. 28.
— —, Anatolia, abs. 69.
— —, Arabistan, abs. 69.
— —, Austria-Hungary, Hungary, Almásszelistye, abs. 56.
— —, — —, —, Dobschau, abs. 58.
— —, — —, —, eastern, abs. 66.
— —, Belgium, La Mallieue, abs. 51.
— —, Bolivia, abs. 74.
— —, Brazil, Ouro Preto, abs. 31.
— —, Burma, Nanya-Zeik, abs. 19.
— —, —, Upper, abs. 17.
— —, France, Britanny, Côtes du Nord, Forest of Lorges, abs. 52.
— —, Germany, Bavaria, Fichtelgebirge, abs. 55.
— —, —, Eisenzeche, abs. 54.
— —, —, Thuringian States, Franconian Forest, abs. 53.
Ore-deposits, Kurdistan, abs. 69.
— —, Mexico, Jalisco, abs. 38.
— —, Peru, Apurimac, abs. 86.
— —, —, Cuzco, abs. 40.
— —, —, Huamachuco, abs. 44.
— —, —, Huancavelica, abs. 42.
— —, —, Santiago de Chuco, abs. 47.
— —, Portugal, abs. 8.
— —, Queensland, Herberton district, abs. 78.
— —, Rumania, Moldavia, Brosteni, abs. 61.
— —, Russia, Urals, southern, Komarovo, abs. 62.
— —, —, —, —, Zigaza, abs. 62.
— —, Spain, abs. 8.
— —, —, Galicia, Pontevedra, abs. 14.
— —, —, Granada, Sierra Nevada, abs 13.
— —, —, León, Palencia, northern, abs. 2.
— —, —, Murcia, Cartagena, abs. 4.
— —, —, New Castille, Ciudad Real, abs. 3.
— —, —, tertiary rocks, early and middle, abs. 6.
— —, Swiss Jura, abs. 63.

P.

Papp, Karl von, Almásszelistye ore-deposits, Hungary, abs. 56.
Patrons, list, app. iii., xviii.
Pedelty, Simon, *repairing leaky seams*, 33.
Peru, Apurimac, mineral resources, abs. 86.
—, Cuzco, mineral resources, abs. 40.
—, Huamachuco, mineral resources, abs. 44.
—, Huancavelica, mineral district, abs. 42.
—, northern, petroliferous belt, abs. 72.
—, Salinas, borax-deposits, abs. 39.
—, Santiago de Chuco, mineral resources, abs. 47.
—, tin, prospecting for, abs. 74.
Petroleum, Africa, Angola, abs. 29.
—, —, Orange Free State, abs. 72.
Petroleum, Africa, Portuguese West, Angola, abs. 29.
—, Peru, northern, abs. 72.
Phosphate-mining, Belgium, abs. 83.
Phosphatic deposits, Africa, Algeria, abs. 23.
— —, —, Tunis, abs. 23.
Pilz, R., metalliferous deposits of Cartagena, Spain, abs. 4.
Plumbarseniferous mineral, georgiadesite, abs. 81.
Plumbiferous deposits, Spain, Granada, Sierra Nevada, abs. 13.
Poland, Russian, Dombrowa, coal-field, abs. 60.
—, —, —, — —, fossil plants, abs. 80.
Portugal, mineral resources, abs. 8.
Pumps, wooden, found in Rainton colliery, 92.

Q.

Queensland, Herberton district, tin-ore deposits, abs. 78.
Quicksilver-mines, Mexico, Bella Union, abs. 36.

R.

Rainton colliery, old wooden pumps found in, 92.
Rauw, H. de, zinc-ores of La Mallieue, Belgium, abs. 51.
Reading, writing, and smoke rooms, 134.
Redlich, K. A., Dobschau ore-deposits, upper Hungary, abs. 58.
Redmayne, R. A. S., report on causes of and circumstances attending underground fire which occurred at Hamstead colliery, on 4th March, 1908.—Discussion, 47.
Repairing leaky seams, 31, 94.
Representatives on council of The Institution of Mining Engineers, election, 14.
Resow, —, Eisenzeche iron-ore belt, Germany, abs. 54.
Rigaudias, —, dust-explosion at Gardanne mine, France, abs. 96.
Rippas, P., E. Ahnert, M. Ivanov, and A. Khlaponin, recent surveys in gold-bearing regions of Siberia, abs. 21.
Romaño, E. A. L. de, stanniferous deposits of Bolivia and prospecting for tin in Peru, abs. 74.
Ross, Arthur, circulation and heat absorption in steam boilers.—Discussion, 23.
Ross, J. A. G., *circulation and heat absorption in steam boilers*, 26.
Rossenbeck, —, electric safety-lamp experiments at Camphausen, Germany, abs. 93.
Ruby-deposits, Burma, Nanya-Zeik, abs. 19.
Rumania, Moldavia, Brosteni, manganiferous iron-ore deposits, abs. 6.
Russia, Urals, southern, Komarovo, iron-ore deposits, abs. 62.
—, —, —, Zigaza, iron-ore deposits, abs. 62.
Russian Empire, salt-mining industry, abs. 102.
— —, Siberia, Bureia basin, jurassic coal-seams, abs. 68.
— —, —, gold-bearing regions, surveys, recent, abs. 21.
— —, —, south-western, Akmolinsk district, Kirghese Steppe, coal-mining, 99.
— —, —, Yenisei basin, brine-springs, abs. 20.
— —, —, — —, Glauber's salt-deposits, abs. 20.
— —, —, — region, auriferous deposits, abs. 67.
Rutherford, William, *notes on small contrivance to more easily detect fire-damp*, 132, 133.

S.

Safety-fuzes, France, abs. 89.
Safety-lamps, electric, experiments, Germany, Camphausen, abs. 93.
— —, French glass for, new, abs. 95.
— —, Müller, abs. 95.
St. Étienne coal-field, Montrambert and La Béraudière collieries, working of inclined seams, 56, 110.
Salt-deposits, Glauber's, Russian Empire, Siberia, Yenisei basin, abs. 20.

Salt-mining industry, Russian Empire, abs. 102.
Santolalla, Fermín Málaga, mineral resources of province of Huamachuco, Peru, abs. 44.
—, — — — — — Santiago de Chuco, Peru, abs. 47.
Santos, B. J. dos, search for coal in southern Brazil, abs. 31.
Schmidt, Albert, cupriferous and nickeliferous deposits in Franconian Forest, Germany, abs. 53.
—, gold-mining in Fichtelgebirge, Germany, abs. 83.
—, specular iron-ore of Fichtelgebirge, Germany, abs. 55.
Schneider, Julio, Cobquecura brown-coal deposit, Chile, abs. 34.
Schutten, A. de, and A. Lacroix, georgiadesite, a new plumbarseniferous mineral, abs. 81.
Seams, leaky, repairing, 31, 94.
Sena, Joaquim Candido da Costa, zinc-blende deposit in Ouro Preto, Brazil, abs. 31.
Severs, William, *notes on small contrivance to more easily detect fire-damp*, 132.
Shamrock I. and II. colliery, Germany, Westphalia, Herne, hydraulic stowing of gob, 111.
Shipment, coal, and laying-out of staithe heads, with special reference to anti-breakage appliances, 136.
Simmersbach, Bruno, mineral resources of Anatolia, Kurdistan and Arabistan, abs. 69.
Smoke, reading, and writing rooms, 134.
Société de l'Industrie Minérale, report of delegate to jubilee meeting of, 1908, 15.
Spain, Galicia, Pontevedra, stanniferous deposits, abs. 14.
—, Granada, Sierra Nevada, plumbiferous deposits, abs. 13.
—, León, Guardo, coal-field, abs. 1.
—, —, Palencia, northern, cupriferous deposits, abs. 2.
—, mineral resources, abs. 8.
—, Murcia, Cartagena, metalliferous deposits, abs. 4.
—, New Castille, Ciudad Real, manganese-ores, abs. 3.
—, tertiary rocks, early and middle, mineral deposits, abs. 6.
Staithe heads, coal-shipment and laying-out of, with special reference to anti-breakage appliances, 136.
Stanley, G. H., note on deposit of sulphur in colliery water, 41.—Discussion, 42.
—, — — effect of igneous dyke on Natal coal-seam, 38.—Discussion, 39.
Stanniferous deposits, Bolivia, abs. 74.
— —, Spain, Galicia, Pontevedra, abs. 14.
Steam boilers, circulation and heat absorption in, 23.
Steamers, coal cargo-, short description of various types, and of Doxford's new self-discharging steamer, 254.
—, Doxford's new self-discharging, short description of, 254.
Steavenson, A. L., safety-lamp for detecting small quantities of inflammable gas, 44.—Discussion, 46.
Stowing of gob, hydraulic, Shamrock I. and II. colliery, Herne, Westphalia, Germany, 111.
Strzelecki, Percy, list of fatal and non-fatal explosions of fire-damp or coal-dust, and barometer, thermometer, etc., readings for the years 1907 and 1908, abs. 105.
Students, election, 15, 46, 94, 109, 253.
—, list, app. iii., lvi.
Subscribers, election, 46.
—, list, app. iii., lviii.
Subsidence, surface and underground, in coal-mining, abs. 91.
Subsidences, unwatering of strata and, Germany, Rhenish-Westphalian coal-field, abs. 91.
Sulphur, deposit of, in colliery water, 41.
Sulphur-deposits, Mexico, Durango, Mapimí, abs. 76.
Surface subsidence in coal-mining, abs. 91.
Surveys, recent, Russian Empire, Siberia, gold-bearing regions, abs. 21.
Sutherland, A. Munro, *short description of various types of coal cargo-steamers and of Doxford's new self-discharging steamer*, 275.
Swiss Jura, iron-ores, abs. 63.
Switch, box-, and box-controller, Bold, 35.

T.

Tanatar, J. J., ruby-deposits of Nanya-Zeik, Burma, abs. 19.
Tate, Simon, *notes on small contrivance to more easily detect fire-damp*, 131.
Terry, Arthur M., *repairing leaky seams*, 34.
Tertiary rocks, early and middle, Spain, mineral deposits, abs. 6.
Thermometer, barometer, etc., readings, 1907 and 1908, abs. 105.
Thiess, F., salt-mining industry in Russian Empire, abs. 102.

Thompson, J. G., Bold box-controller and box-switch, 35.
Tietze, O., phosphate-mining in Belgium, abs. 83.
—, phosphatic deposits of Algeria and Tunisia, abs. 23.
Tin, Bolivia, abs. 74.
—, Peru, prospecting for, abs. 74.
—, Queensland, Herberton district, abs. 78.
Toborffy, Zoltán von, jánosite identified with copiapite, abs. 82.

U.

Underground fire at Hamstead colliery, report on causes of and circumstances attending, 47.
— fires in mines, abs. 100.
— subsidence in coal-mining, abs. 91.
United Kingdom, explosions of fire-damp or coal-dust, fatal and non-fatal, list, 1907, abs. 105.
United Kingdom, explosions of fire-damp or coal-dust, fatal and non-fatal, list, 1908, abs. 105.
— States of America, Colorado, coals, abs. 49.
Unwatering of strata and subsidences, Germany, Rhenish-Westphalian coal-field, abs. 91.

V.

Velarde, Carlos E., mineral district of Huancavelica, Peru, abs. 42.
Villarello, Juan D., Bella Union quicksilver-mines, Mexico, abs. 36.
Villarello, Juan D., sulphur-deposits of Mapimí, Mexico, abs. 76.
Voit, F. W., South African diamantiferous deposits, abs. 70.

W.

Washington "Glebe" colliery, explosion, 54.
Water, colliery, deposit of sulphur in, 41.
Watson, Edward, coal-mining on Kirghese Steppe, in Akmolinsk district of south-western Siberia, 99.—Discussion, 107.
—, *report on causes of and circumstances attending underground fire at Hamstead colliery*, 51.
Wedging, coal-, König and Gützlaff machine, abs. 88.
Wilson, H. M., *short description of various types of coal cargo-steamers and of Doxford's new self-discharging steamer*, 277.
Wilson, W. B., *notes on small contrivance to more easily detect fire-damp*, 132.
Wilson, W. B., Jun., *note on deposit of sulphur in colliery water*, 43
Wood, E. Seymour, *notes on small contrivance to more easily detect fire-damp*, 280.
Wooden pumps found in Rainton colliery, 92.
Working of inclined seams in St. Étienne coal-field, at Montrambert and La Béraudière collieries, 56, 110.
Writing, reading, and smoke rooms, 134.

Y.

Yarza, R. A. de, cupriferous deposits of northern Palencia, Spain, abs. 2.

Z.

Zaliessky, M. D., fossil plants of Dombrowa coal-field, Russia, abs. 80.
Zeiller, R., and H. Douvillé, coal-measures in southern Oran, Algeria, abs. 22.
Zeiller, R., — Courtillon, H. Lantenois, L. Laurent, and H. Mansuy, coal-mines, etc., of southern Yunnan, China, abs. 15.
Zinc-blende deposits, Brazil, Ouro Preto, abs. 31.
Zinc-ores, Belgium, La Mallieue, abs. 51.

TN
1
N8
v.58-
59

North of England Institute
of Mining and Mechanical
Engineers, Newcastle-upon-
Tyne
Transactions

Engineering

~~Physical &~~
~~Applied Sci.~~
~~Serials~~

PLEASE DO NOT REMOVE
CARDS OR SLIPS FROM THIS POCKET

UNIVERSITY OF TORONTO LIBRARY

ENGIN STORAGE